Exploring the interaction between Schizotypy personality and Working Memory on Speech illusions

Tristan Lyon Chooi

BPyschSc

A report submitted in partial requirement for the degree of Bachelor of Psychological Science (Honours) at the University of Tasmania 2019.

Statement of Source

I declare that this report is my own original work and that the contributions of others have been duly acknowledged.

Signature: Date: 17.10.19

Acknowledgements

I would like to take this opportunity to acknowledge the contributions of my parents whom made this possible. It is their hard work and sacrifice that allowed me this opportunity to learn and grow in this institution. I want you to know that your care, warmth, and sacrifice has played an immensely huge role in motivating me to become the best version of myself. Thank you, for being the most supportive family I could ever ask for. I would also like to thank my supervisor, Dr Michael Quinn, whom have been a huge support throughout the course of this thesis. From dealing with my constant emailing, to responding to my 5-minute queries on skype during the weekends, thank you for guiding me. To Rachel, my lab buddy, who spent countless hours with me in the lab running our study. Doing research together with you has been an honour. To my partner, Alexis, your constant love and reminders for me to take breaks and eat meals have probably saved me from countless breakdowns. Thank you for constantly being my pillar of support and encouragement, I can only hope to be the same for you. To my sister, I do not say this enough, but I want you to know that I am very appreciative of all the little things you do for me. To my close friends (Weiming, Zoul, Will, Indah, Fathoum, Zhi), thank you for constantly being there for me and supporting me. This journey was a lot easier with you guys by my side. To my classmates (Megan, Katie, Erin), who have been dealing with my constant messaging at 3 a.m. I am sure I have caused plenty of anxiety throughout the year, thank you for being patient. Last but not least, to everyone else who participated in this study, this research would not have been possible with you. Once again, to all the people that have helped me throughout this journey, thank you, the accomplishment of finishing this thesis is as much yours as it is mine.

Table of Contents

List of Figures

List of Tables

Exploring the interaction between Schizotypy personality and Working Memory on Speech illusions

Tristan Lyon Chooi

9461 Words

Abstract

This study used the schizotypy personality as a proxy for schizophrenia to understand the mechanisms underlying speech illusions – the perception of meaningful speech in ambiguous auditory signals - in a normative population. To assess the interaction between working memory and schizotypy personality on speech illusions, Hoffmann's (1999) Multi-speaker babble task was used. We hypothesized that individuals high on the schizotypy spectrum and with a lower working memory would score higher on the babble task, compared to high schizotypic individuals with higher working memory. Sixty-two participants completed the babble task, measures of schizotypy personality, and measures of working memory. Moderation analyses were conducted to assess the interaction between the level of schizotypy and the different aspects of working memory on the babble task. Contrary to the hypothesis, it was found that high schizotypic individuals who had a higher auditory/visual verbal working memory were able to detect more words in the babble task. The interaction between working memory and liabilities to speech illusions on the babble task in this normative sample differed from those found in prior research in clinical/subclinical populations. This suggests that the mechanisms underlying speech illusions experienced by the general population might be different from those in clinical population.

Multi-Speaker Babble Task

Signal detection paradigms are often used to examine an individual's proneness to speech illusion. This experimental design involves participants discriminating audible words through various control measures, allowing researchers to quantitatively measure an individual's tendency towards the false perception of signals (Hoffmann, Rapaport, Mazure & Quinlan, 1999). There are many variations of the speech detections paradigm, but in this study, the multi-speaker babble task (MSBT) designed by Hoffmann et al (1999), is used to identify individuals that are able to extract spurious messages from meaningless babble.

The MSBT is used as it allows for a more objective measure of speech illusions through experimental manipulations as compared to subjective self-report measures or traditional interview assessments. Furthermore, the MSBT has also been validated to be able to detect individuals with lower threshold levels of speech illusions as compared to the traditional self-report measures (Gupta, DeVylder, Auerbach, Schiffmanm & Mittal, 2018).

During the MSBT, participants are tasked to listen to an audio recording of 12 digitally superimposed speech segments. These 12 speech segments are derived from six readers, three females and three males, who recorded two speech segments each. Each pre-recorded speech segment consists of a reader reading a neutral text which are then overlapped into an audio recording and heard simultaneously by the listener. The resulting stimulus is hence a meaningless babble-like noise or "white noise" (Hoffmann et al., 1999). The combined audio recording, approximately two minutes in length, is presented to participants through an audio listening device, and participants are asked to speak any words or chain of words that they hear during the task. Two scores are gained from the MSBT, the number of words heard, as well as the longest chain of consecutive words (CCW). The longest chain of consecutive words refers to the longest phrase heard during the MSBT.

Speech Illusions

Speech illusions or misperceptions, as distinct from hallucinations, are generally used to describe incorrect perceptions of stimuli (Brasic, 1998; Komel, 1993). Speech illusions are a type of auditory misperception that can be defined as the tendency to extract meaningful speech or words in phonetically ambiguous situations; for instance, having the tendency to hear discernible words or speech from a television set that is playing static noises. The effect of speech illusions may vary depending on individuals, and it ranges from being an adaptive trait to an aberrant phenomenon (Galdos et al., 2010). In its extremity, speech illusions may resemble a psychotic-like experience that can be distressing for the individual, and extreme liability to speech illusions can be an indicator of an individual's liability for psychotic disorders (Briebrion et al., 2015).

Theories underlying speech illusions. At present, there are several theories that may explain speech illusions. Dolgov and McBeath (2005) proposed a theoretical framework that explain~~s~~ the occurrence of speech illusions in the absence of perceptual deficits. In their framework, the 'voices' heard in speech illusions are explained by an amplified perceptual enhancement caused by individual differences in response bias – an individual criterion for deciding whether a perceived event is an actual stimulus. Dolgov and McBeath (2005) also proposed that the response bias is not only modulated by individual differences but also attentional processes. Hence, when an attentional bias is present, it allows the individual to recognise weakly indicated auditory signals (Dolgov & McBeath, 2005). While advantageous in certain scenarios, this amplified sensitivity in detecting ambient stimuli may result in the detection of signals that is not present, thus resulting in speech illusions or auditory misperception.

Hoffmann et al. (1995) posited that speech illusions and auditory hallucinations are caused by diminished neuroanatomic connectivity in the verbal working memory. By using a neural network computer simulation, the researchers were able to simulate a deficient verbal working memory system by pruning anatomic connection and reducing neuronal activation. Findings from the study found that word “precepts” emerge in the absence of auditory stimuli, thus suggesting that the neuronal connections in the working memory systems may play a role in the production of auditory verbal hallucinations. To this point, auditory verbal hallucinations (AVH) are distinctively different from speech illusions as AVH refers to the discrimination and perception of speech in the absence of auditory signals.

Link between speech illusions and AVH. Empirical research has been consistent in finding a positive association between the severity of speech illusions and AVH. In clinical populations, Hoffmann et al. (1999) conducted and compared the MSBT scores between hallucinating patients with schizophrenia, non-hallucinating patients with schizophrenia, and healthy controls. The researchers found that the patients with schizophrenia that exhibited hallucinatory symptoms displayed a greater amount of word perception deficits. This manifested in perceiving more meaningful words and longer chain of consecutive words on the MSBT - than healthy controls and non-hallucinating patients with schizophrenia. In a follow-up study by Hoffmann et al. (2007), the researchers administered the MSBT to a group of individuals with prodromal symptoms of psychosis (i.e. attenuated positive symptoms). The researchers found that the higher MSBT score positively predicted the conversion of prodromal symptoms to clinically diagnosed schizophrenia. In Gupta et al. (2018), researchers conducted the MSBT in a subclinical population and found a positive correlation between speech illusions measured by the MSBT and proneness to experience hallucinations. The findings from the studies thus suggest that the interaction between speech illusions and AVH in clinical, prodromal, and subclinical populations may be more similar than expected. Further research on speech illusions present in nonclinical populations may thus be needed in order to gain a deeper understanding of the mechanisms underlying speech illusions, that may consequently aid our understanding of auditory verbal hallucinations.

Schizotypy

Schizotypy can be described as a multi-dimensional personality type that exists on a continuum of severity, universal to the populace. Schizotypy personality traits have been suggested to be a healthy personality variant of schizophrenia-like symptomology expressed by the normative population (Lezenweger, 2018). While there has been dispute on the number of underlying factors explaining this personality style, the prevailing understanding is that it is comprised of three main identifiable factors that reflect similarly as the positive, negative, and disorganised factors of schizophrenia (Stefanis et al., 2004; Mason & Claridge, 2006; Fonseca-Pedrero et al., 2011; Wuthrich & Bates, 2006). The cognitive-perceptual factor comprises unusual perceptual experiences, magical thinking, ideas of reference and paranoia (Raine, 1991; 2006). The interpersonal factor encompasses social anxiety, the lack of close relationships, constricted effect and suspiciousness (Raine, 1991; 2006). The disorganised factor covers odd speech and odd behaviours (Raine, 2006).

In essence, individuals high on the schizotypy spectrum may express a cognitive style similar to individuals with schizophrenia-related disorders but are distinctively different from schizophrenia patients as they are non-pathological and belong to a healthy population (Kwapil & Barrantes-Vidal, 2015). Additionally, individuals high on the schizotypy spectrum have been known to exhibit adaptive strength in creativity, displaying an inclination towards creative activities such as music, painting and even gardening (Batey & Furnham, 2008; Rawlings & Locarnini, 2008; Nelson & Rawlings, 2010). Thus, the study of schizotypy personality offers researchers a unique insight by allowing the study of unusual perceptual experiences in a healthy population free of psychotic illnesses and extraneous factors such as iatrogeny and medication (Heron, Jones, Williams, Owens, Craddock, & Jones, 2003).

Theories underlying schizotypy. There are two main models that can be used to describe the distribution of schizotypy in the general population, and its relation to schizophrenia-spectrum psychopathology. Firstly, there is the quasi-dimensional model of schizotypy that is based upon a disease model of mental illness (Nelson, Seal, Pantelis, & Phillips, 2013). Meehl's (1963) quasi-dimensional model of schizotypy suggests that schizotypy affects a small proportion of the population. This small percentage of people are predisposed to a specific genetic liability that causes an aberration in the neural transmission. It has also been suggested that this genetic liability interacts with other factors to cause a transition towards schizophrenia, schizophrenia-spectrum disorders, non-psychotic states or even normalcy (Lezenweger, 2006). However, there is a lack of evidence to support Meehl's (1963) model of schizotypy, and an alternative model, the fully dimensional model, is currently the dominant model of understanding schizotypy (Claridge, 1997; Claridge & Beech, 1995).

The main difference of the fully dimensional model, in comparison to the quasi-dimensional model, is that this model posits schizotypy to exist as a personality construct that affects all members of the population (Claridge, 1997; Claridge & Beech, 1995). Based on the fully dimensional model, the personality organisation of schizotypy applies to the general population, and varies in severity, with the level of schizotypy correlating with the severity of schizophrenia-like symptomology. Furthermore, the fully dimensional model asserts that schizotypy exists as a personality construct, which in its extremity, may pose as a risk factor that could manifest into clinical disorders (Rawling, Williams, Haslam, & Claridge, 2008). When an individual with high schizotypy interacts with other aetiological risk factors, that individual may have an increased risk of developing schizophrenia or other schizophrenia-spectrum disorders (Rawling et al., 2008). However, for the purpose of this study, we will be looking at schizotypy in a healthy population sample.

Schizotypy and speech illusions. In relation to speech illusions experienced by the general population, a study by Galdos and colleagues (2011) found that healthy individuals that scored high on schizotypy personality traits detected more speech illusions, measured by the white-noise task, as compared to individuals low on schizotypy traits. Other studies have also found similar findings, of a positive correlation between the level of schizotypy and severity of speech illusions (Barkus et al., 2007; Barkus et al., 2010). The association between the level of schizotypy and speech illusions can be traced to the cognitive perceptual factor of the schizotypy personality, and more specifically, the unusual perceptual experience subfactor. As such, individuals high on schizotypy spectrum are more likely to experience unusual perceptual experiences such as speech illusions as compared to low schizotypic individuals. By using the personality organisation of schizotypy, it allows researchers to study the liabilities to speech illusions in a fully normative population.

Working Memory

Working memory has also been found to influence scores on the MSBT (Hoffmann et al., 1999). In a clinical study by Hoffmann et al. (1999), researchers found that among hallucination-prone individuals with schizophrenia, individuals with a lower working memory tend to score higher on the MSBT (i.e. perceive more words) as compared to those with a higher working memory.

Baddeley's (1986) model of working memory is a key hypothetical system that explains how sensory information that individuals receive are temporarily maintained, manipulated, and integrated with task-relevant information to relevant outputs. In essence, it refers to the brain's ability to perform mental manipulations by integrating new information with existing ones. Baddeley's (1986) working memory model consists of 3 parts - the visuospatial sketchpad and phonological loop component that are involved in the short-term storage of visual and verbal information, and the central executive component that is involved in the control and manipulation of information held within the phonological loop and visuospatial sketchpad.

Working memory may play a role in speech detection through semantic and syntactic expectations. Research has found that on a single word level, a single verb generates semantic expectations about an upcoming noun, and syntactic expectation helps guide the semantic process (Friederici, Steinhauer, & Frisch, 1999; Gunter, Friederici, & Schriefers, 2000). Syntactic and semantic expectations play a critical role in speech detection as normal spoken speech often consists of acoustic ambiguity due to blurring of phonetic information or background noises (Kalikow & Stevens, 1977; Warren & Warren, 1970). Semantic and syntactic expectations help to resolve the acoustic ambiguity by piecing and formulating coherent sentences together (Friederici, Steinhauer, & Frisch, 1999). Multiple empirical studies have supported this view by comparing noise-contaminated speech with and without semantic or syntactic word structure; finding that semantic and syntactic expectation helps facilitate speech detection (Friederici, 1983; Goodman, McClelland, & Gibbs, 1981; Katz, Boyce, Goldstein, & Lukatela, 1987; Marslen-Wilson & Tyler, 1980). This indicates that having a stronger working memory would likely facilitate linguistic expectations and increase the likelihood of speech detection. However, Hoffmann et al. (1995) has suggested that in perceptually deficient individuals, a reduction in the network connectivity in the verbal working memory system beyond a certain threshold could cause linguistic expectations to become disordered and consequently lead to the misperception of signals (i.e. speech illusions) and spontaneous generation of new signals (i.e. auditory hallucinations).

Working memory and auditory illusions. Existing studies in schizophrenic populations indicate a negative association between working memory deficits and auditory illusions. In a study conducted by Brebrion et al. (2015), researchers found that individuals with schizophrenia, and have a lower working memory tend to perceive more auditory illusions (Brebrion et al., 2015; Gisselgard et al, 2014). Similarly, hallucinating individuals with schizophrenia were also found to experience deficits in verbal working memory. The commonalities in these studies supports Hoffmann et al (1995) theory of speech illusions, that working memory may play a significant underlying role in the process of both AVH and speech illusions in clinical populations.

Presently, there is only one study, by Gupta et al. (2008), which has attempted to investigate the interaction between working memory and liabilities to speech illusions in a non-clinical population. The study was conducted on a group of participants, separated into high hallucination proneness and low hallucination proneness. Hallucination proneness was measured through the Launay Slade Hallucination Scale-R self-report questionnaire (LSHS-R), to identify psychotic-like experiences in the general population (Bentall & Slade, 1985). In the study, the MSBT, together with several other working memory tasks, were conducted on the participants to assess how working memory interacts with hallucination prone individuals from the normative population. Researchers found that individuals in the high hallucination prone group demonstrated higher levels of speech illusions on the MSBT as compared to low hallucination prone group. More importantly, there was a significant interaction between hallucination proneness and working memory on the MSBT score. Within the high hallucination prone group, individuals with a lower working memory tend to score higher on the MSBT as compared to those with a higher working memory. As the interaction between working memory and hallucination prone individuals in the general populations closely resembles the clinical population, it suggests that working memory may play a role in the facilitation of speech illusions in normative populations.

Aims and Hypothesis

This study was designed to follow-up the study conducted by Gupta et al. (2018) but using schizotypy rather than the concept of hallucination proneness. A different construct needed to be considered because the construct of hallucination proneness does not accurately encapsulate the general population. Individuals that are hallucination prone, as measured by the LSHR-R scale, likely have significant cognitive vulnerability towards hallucinations, and they could be considered as a sub-clinical group or “at-risk” group (Bentall & Slade, 1985). On the other hand, schizotypy is a personality type that exists in every individual.

While individuals that score high on the schizotypy spectrum may share similar liabilities to speech illusions as individuals with schizophrenia, but they are healthy individuals that are representative of the normative population. In this study, we aim to investigate whether working memory interacts with the level of schizotypy, to affect scores on the MSBT. We seek to replicate the aforementioned interaction between hallucination proneness and working memory on MSBT scores seen in clinical and subclinical populations to understand its applicability in a normative population. If high schizotypic individuals with a lower working memory scored higher on the MSBT than those with a higher working memory, then it indicates that susceptibility to speech illusions may be a combination of both cognitive style and working memory capabilities. This would thus give us a better understanding of the mechanisms underlying speech illusions in the normative population and allowing us to compare it with existing research on speech illusions in clinical populations.

Taking reference from previous studies, we hypothesize that (1) individuals high on the schizotypy spectrum would score high on the MSBT, (2) working memory would be inversely related with scores on the MSBT, and (3) there will be an interaction between working memory and level of schizotypy, such that high schizotypic individuals with lower working memory would perceive more speech illusions as measured by the MSBT as compared to those with higher working memory.

Method

The data used in this study was obtained as part of a study with an overarching ethics approval from the Tasmanian Social Science Human Research Ethics Committee (ref: H0018214). The approval letter is shown in Appendix F.

Participants

Sixty-two participants (28 males, 24 females) aged between nineteen and fifty-two years old (*M*=23.97 years, SD=4.33), were recruited through convenience sampling and from the University of Tasmania SONA Psychology research participant system (SONA). Participants were entered into a draw to win one of five $30 gift vouchers. First year Psychology students could alternatively choose to receive one (1) hour of research participation credit.

Participants who, had currently, or had a history of psychosis or schizophrenia-related disorders were excluded from the study. As the study involves participants picking out words in a noise-like condition, participants who have experienced auditory hallucinations tend to perform differently on this task. Participants with first-degree relative with schizophrenia-related disorders were also excluded from the study as these individuals are more susceptible to auditory misperception and may performs differently on the MSBT. Lastly, participants with hearing problems were excluded as hearing problems might affect the individual’s capacity to perform the MSBT.

Materials

Multi-Speaker Babble Task (MSBT). The MSBT used in this study was designed by Hoffmann (1999), which identifies individuals who are prone to detecting meaningful words in phonetically ambiguous speech. The multi-speaker babble audio recording consists of twelve narrative texts (neutral texts from fiction and popular magazines ranging from 90 to 135 words) read by three male and three female speakers (2 passages each), at a rate of 2.20 words per second (SD=0.21). The 12 narrative speeches were then digitally superimposed into an audio recording of 110 seconds, resulting in a steady stream of unintelligible speech that sound~~s~~ like a noise-like babble. After putting on a pair of noise isolation headphones, participants are asked to listen to the audio recording and were instructed to repeat aloud any discernible words or phrases they perceived.

In line with existing literature, there are two components to the scoring of the MSBT. Firstly, the number of words uttered by the participant is calculated, and secondly, the number of words in the longest chain of consecutive words (CCW) the participant perceives is scored (Hoffmann et al., 1999; 2007). The responses from the participants on the MSBT were transcribed by the researchers during the task, and they were also audio recorded through a microphone to assist in verifying any missing or ambiguous information.

Schizotypal Personality Questionnaire, Brief Revised Updated (SPQ-BRU). The Schizotypal Personality Questionnaire Brief Revised Updated (SPQ-BRU) was used in this study as a measure of schizotypy personality (Davidson, Hoffman, & Spaulding, 2016). The Schizotypal Personality Questionnaire comes in a variety of forms, and it has been a well-validated, popular and widely used measure of schizotypal personality traits (SPQ:

Raine, 1991). The SPQ-BRU (see Appendix C) was used in this study as it is the most recent and best psychometrically validated form of the SPQ (Davidson, Hoffman, & Spaulding, 2016).

The SPQ-BRU contains 32 self-report items that participants rate on a 5-point Likert-type scale, ranging from strongly agree to strongly disagree, with regards to how applicable the statement is to them. The SPQ-BRU measures nine lower-order factors that are theoretically related to schizotypy, and these lower-order factors are grouped into four different high-order factors – cognitive-perceptual factor, social anxiety factor, interpersonal factor and disorganised factor (Davidson, Hoffman, & Spaulding, 2016). Additionally, the SPQ-BRU provides an overall score as a measure of the schizotypy personality dimension as a whole. It is this total score which was used in this study to assess for the level of schizotypy, where higher scores indicate higher levels of the personality.

Millisecond Digit Span Task (MDST). The Millisecond Digit Span Task (Millisecond, 2019; Borchert, 2019) was developed by Woods et al. (2011), and it was used in this study to assess auditory verbal working memory ability. The MDST code used to run the MDST is freely available online on the Millisecond website and was conducted through the Inquisit 5.0 (Millisecond, 2019) program on a Windows-based PC, using noise-isolating headphones and a touch screen response monitor. During the task, participants were asked to put on a pair of noise-isolating headphones to listen to the auditory stimuli before being asked to recall them.

The MDST consists of two components – forward recall and backward recall – each with 14 trials. Each component began with a minimum of two practice trials, and participants only proceeded to the actual testing component when there was at least one correct response on a practice trial. Feedback for the participants was provided on the practice trial, but not on the research trials.

For the forward recall component, each digit was aurally presented through the headphones at an interval of one (1) second. At the end of the digit sequence, a visual cue (red dot) was presented in the middle of the screen for one (1) second, and then the screen shown in Figure 1 was displayed. Participants would then tap on the touch screen monitor and key the sequence in which the digits were presented to them (i.e. if presented 1, 2, 3, 4, forward recall is 1, 2, 3, 4). The task began with three digits, and if a correct response was provided, the participant would move to the next level and the number of digits would increase by one. If an incorrect response was made, the same level was presented again. If consecutive errors at the same level were made, the participant would move down a level, and the number of digits would decrease by one before repeating the process. The task ended after the participant completed 14 trials.

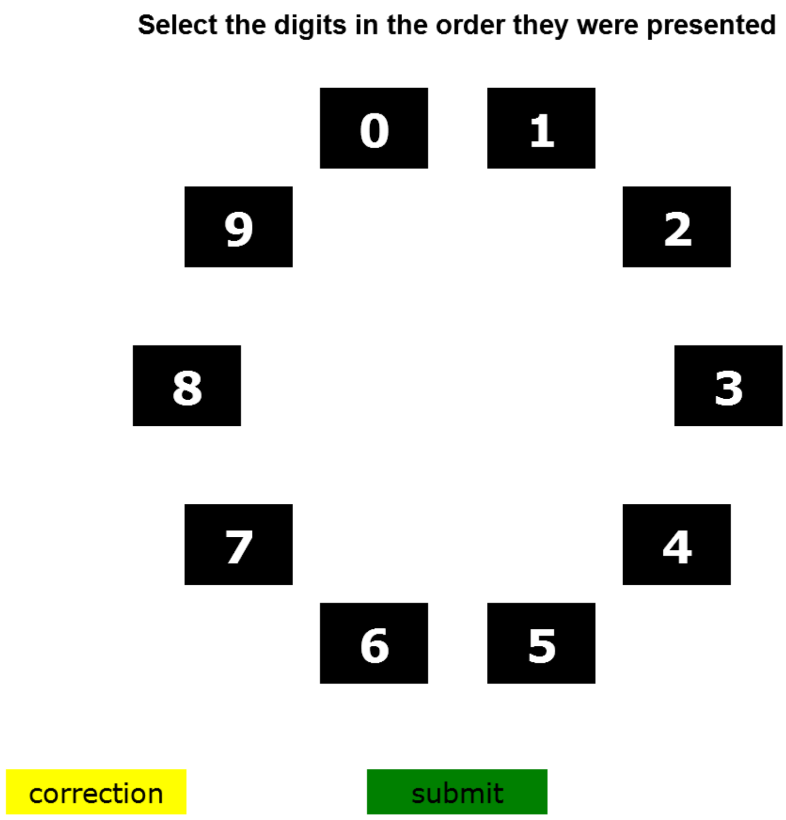

Figure 1. Screenshot of the response screen used by participants in the Auditory Digit Span Task. Participants tapped their responses on the touch screen monitor showing this image.

The backward recall component is similar to the forward recall, but participants were required to recall the digit sequence presented aurally in a reversed order (i.e. if presented 1, 2, 3, 4, backward recall is 4, 3, 2, 1). Upon completion of both the forward and backward recall components, the digit span task would be completed. Participants were scored based on the number of digits in the highest level achieved before two consecutive errors were made. The backward digit span score was used in the analysis as it most closely replicated the auditory letter-number sequencing task used by Gupta et al. (2018).

Millisecond Letter Number Sequencing Task (MLNST). The Millisecond letter-number sequencing task was used to assess visual verbal working memory. The code used to run the MLNST is freely available online on the Millisecond website, and it was conducted via the Inquisit 5.0 (Millisecond, 2019) program on a window-based computer with a keyboard. In this task, participants first received a sequence of randomly derived letters and numbers on the screen before they were asked to recall them by typing it on a standard keyboard. Each letter and number was presented on the screen one at a time, at an interval of one (1) second per digit/letter.

The MLNST consists of two components – forward recall and reordered recall. Each component began with a minimum of two practice trials, and participants only proceeded to the actual testing component when there was at least one correct response on a practice trial. Feedback for the participants was provided on the practice trial, but not on the research trials.

For the forward recall component, participants were tasked to recall the number and letters in the exact order that it was presented to them (i.e. if presented 5, D, 3, C, forward recall is 5, D, 3, C). After completing the practice trial, the task would begin at level 3, with a total of 3 characters, comprising of letters and numbers (e.g. 3, A, 5).

Participants were given a maximum two trials on each level, and if a correct response was provided on either trial at a level, the participant would proceed to the next level and the total number of characters/numbers would increase by one (1). As the participant progresses through the levels, each additional letter and numbers added are set in an alternating sequence. If an incorrect response was made, the same level was presented again. The task would end if the participants scored two consecutive incorrect responses at a level.

For the reordered component, participants were tasked to recall the sequence, but in a reordered manner. They had to recall the sequence firstly by the numbers, from smallest to largest, followed by the letters, in alphabetical order (i.e. if presented 5, D, 3, C, the reordered response is 3, 5, C, D). Upon completion of both the forward and reordered components of the task, the MLNST would be completed. Participants were scored based on number of characters in the highest level achieved before two consecutive errors were made. For the analysis, the forward component of the MLNST was used.

Millisecond Corsi Block Tapping Task (MCBTT). The Millisecond CBTT was used in this study to assess spatial working memory, and the implemented version was developed by Kessels et al. (2000) (Psychological corporation, 1997). The code used to run the MCBTT is freely available online on the Millisecond website, and it was conducted through the Inquisit 5.0 (Millisecond, 2019) program on a window-based computer with a touch screen monitor.

Participants were presented with 9 blue boxes against a black background on the screen as shown in Figure 2. The boxes changed colour to yellow, as demonstrated in Figure 3, one at a time, in a pre-fixed sequence at an interval of one (1) second.

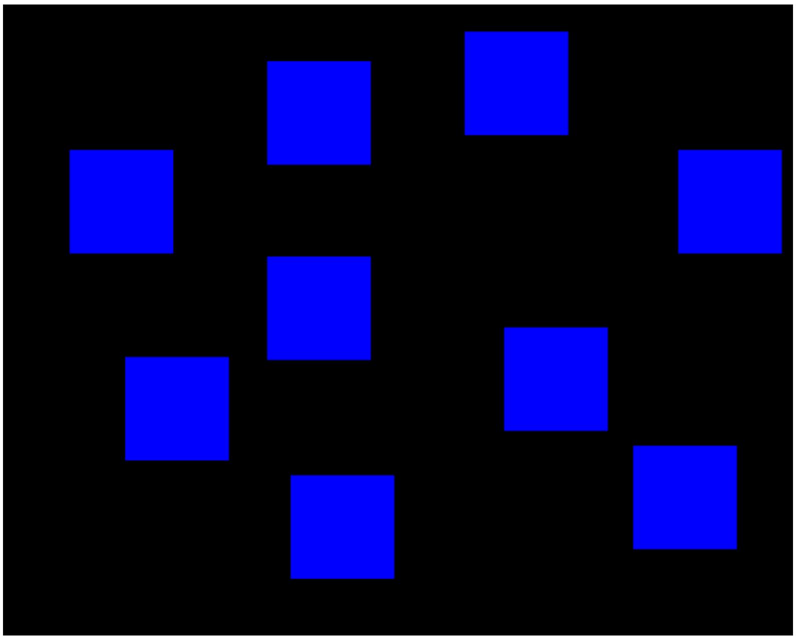

Figure 2. Screen shot of the screen for the Corsi block tapping task. The blue boxes are in the same relative spatial location as seen by participants.

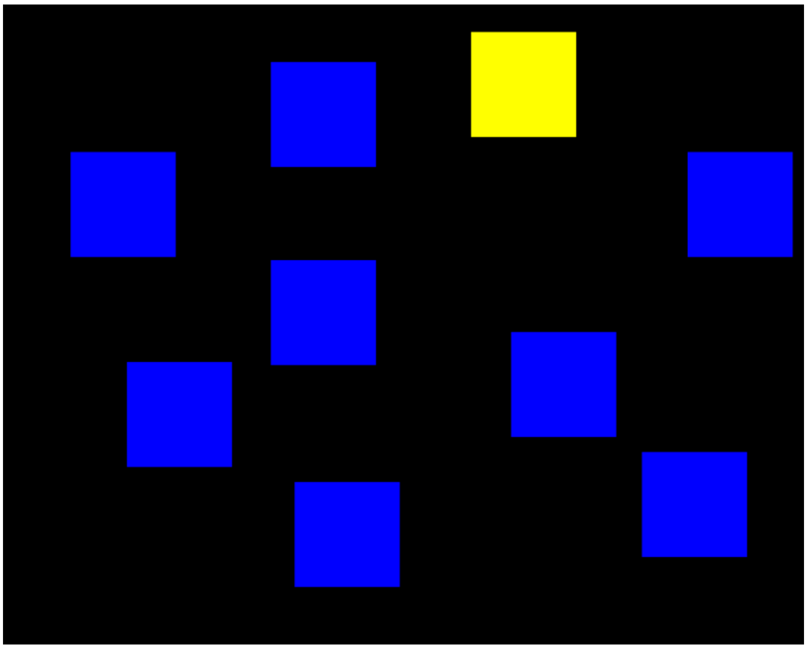

Figure 3. Screenshot of the Corsi block tapping task showing the colouring when box changed colour.

After the sequence was displayed, there was a one (1) second interval before participants were required to use the touchscreen and tap on the blue boxes on the screen in the same order in which the boxes were lit. The sequence length began at level 2, with two boxes being lit, and it could increase to a maximum of level 9, with nine boxes being lit. If participants responded with the correct sequence, they would move up a level and the number of boxes in the sequence would increase by one. If an incorrect response was made, the same level would be presented again. The task would end after participants entered two consecutive incorrect responses at a level. For this task, participants were scored based on the total number of boxes successfully recalled during the trials.

Mini National Adult Reading Test (Mini NART). In this study, the Mini NART (see Appendix B) was used to provide an estimate of intellectual functioning (McGrory, Austin, Shenkin, Starr, & Dreary, 2015). The Mini NART is a shortened form of the National Adult Reading Test (NART), comprising of 23 out of the 50 items in the original NART (NART: Nelson, 1982; Nelson & Willison, 1991). The Mini-NART has been validated to be clinically relevant, consisting of highly discriminatory and invariantly ordered items (McGrory et al., 2015). The Mini-NART has also been developed to allow for a shorter and more concise form to provide an estimate of intelligence while reducing stress and test administration time (McGrory et al., 2015).

As all the working memory tasks used in this study can vary as a function of intellectual functioning, the Mini-NART was used as a covariate in the analysis to control for intelligence as a potential confounding variable. The Mini-NART was scored based on the correct pronunciations of the word.

Procedure

The study was conducted at the Psychology Research Centre on the Sandy Bay campus of the University of Tasmania. Upon arrival, participants were provided with an information sheet (See Appendix D) that described the nature of the study, and they were required to complete a consent form (See Appendix E). Upon gaining informed consent, participants were tasked to complete a screening questionnaire (See Appendix A). Upon completion of the screening questionnaire, participants were tasked to complete the Schizotypal Personality Questionnaire Brief Revised Updated edition (SPQ-BRU) (See Appendix C). After the SPQ-BRU was completed, participants were then tasked to complete the Mini NART (See Appendix B) by reading off the list of words on a laminated sheet. Following the Mini NART, participants were tasked to complete the MSBT. Two different forms of the MSBT was conducted in this study, one at the beginning of testing and the other at the end. As data collection was done with another researcher, we conducted a second form of the MSBT but with a different response format. However, the data from the alternate response format was not used in this study and only data from the traditional MSBT spoken response format was used.

In order to prevent practice effects for the MSBT, half of the participants were tasked to complete the traditional response format MSBT first while the other half completed the alternate response MSBT first.

Upon completion of the MSBT, participants were instructed to complete three working memory tasks through the Inquisit 5.0 (2019) program on a computer. The order of presentation of the working memory tasks was counterbalanced among participants.

Upon completion of the working memory tasks, participants would then complete the second MSBT with a different response format from the first. A visual representation of the procedure is shown in Figure 4.

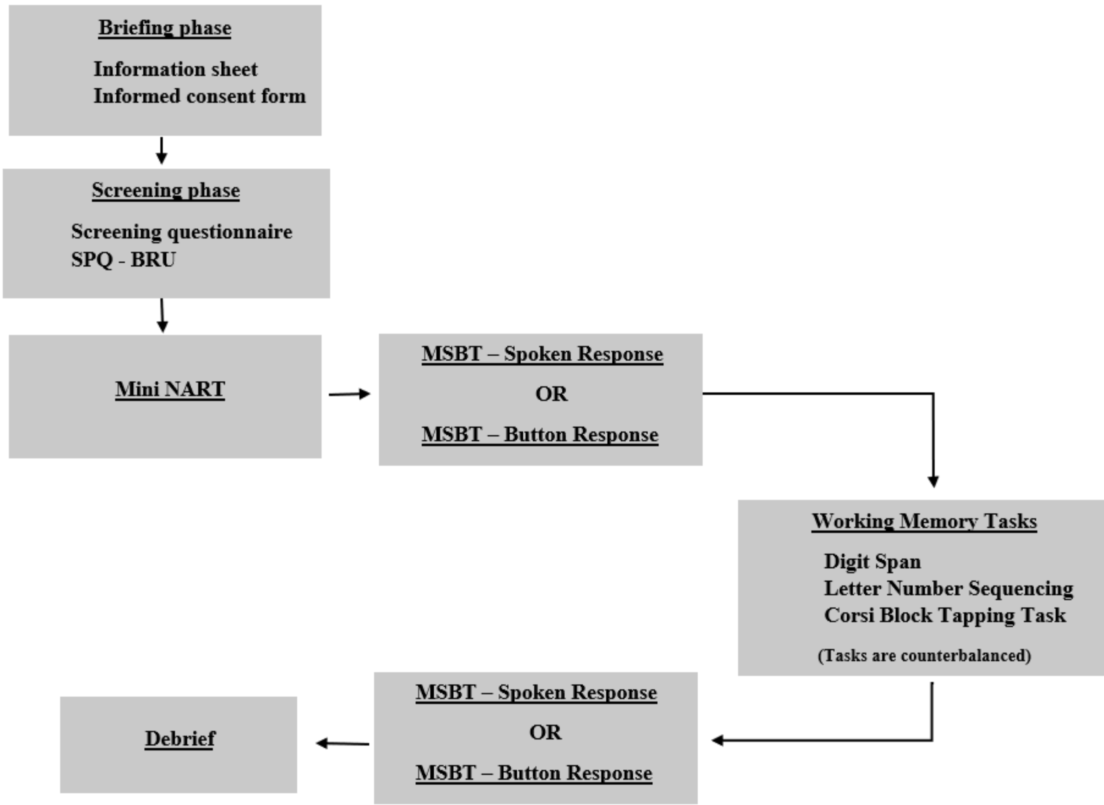

Figure 4. Visual representation of the procedure.

Upon completion of the second MSBT, participants were debriefed and remunerated for their time. In total, research participation took approximately 45 to 60 minutes for each participant.

Results

Data was analysed using SPSS Version 24. One female participant's data was excluded from the analysis due to performance that indicated random responding across all tasks. Another female participant was excluded due to incomplete SPQ-BRU form. This data was analysed on 60 participant's data

Range of Schizotypy

The total score that participants measured on the SPQ-BRU ranged from 45 to 117 (*M*=74.48, SD=17.77). The SPQ-BRU measure has a minimum total score of 32 and a maximum total score of 160. Table 1 describes the range of scores on all four dimensions of schizotypy. A visual representation of the total schizotypy score can be seen in Figure 5. While we had a fairly normally distributed range of schizotypy scores, the range on the schizotypy spectrum was noted to be truncated to the centre of the possible distribution.

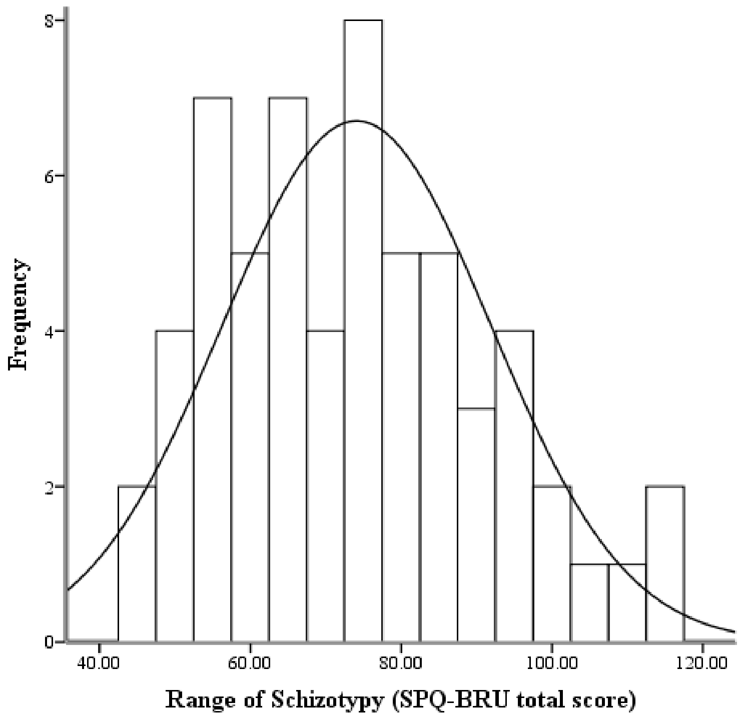

Figure 5. Histogram of the range of total score from the Schizotypy Personality Questionnaire – Brief, Revised Updated (SPQ-BRU) for 60 participants.

Table 1

Descriptive statistics for the Schizotypy Personality Questionnaire – Brief, Revised Updated (SPQ-BRU) (*SPQ-BRU) total score, and each of the 4 major dimensions.*

Descriptive statistics of SPQ-BRU scores						
Measure	N	Range	Minimum	Maximum	Mean	Std. Deviation
SPQ-BRU Total Score	60	72.00	45.00	117.00	74.28	17.77
Cognitive Perceptual Factor	60	29.00	15.00	44.00	27.66	7.51
Interpersonal Factor	60	13.00	6.00	26.00	12.48	5.38
Disorganised Factor	60	16.00	6.00	19.00	12.08	3.51
Social Anxiety Factor	60	4.00	4.00	20.00	11.37	4.34

Association between Schizotypy and the MSBT

The first hypothesis predicted that there would be a positive association between the level of schizotypy and speech illusions as measured by the MSBT, such that as the level of schizotypy increases, scores on the MSBT would also increase.

Pearson correlations between SPQ-BRU total score for both measures on the MSBT were conducted. As can be seen in the scatter-plot in Figure 6, there was no significant correlation between the level of schizotypy and the number of words detected in the MSBT, r=.122, p=.354, n = 60.

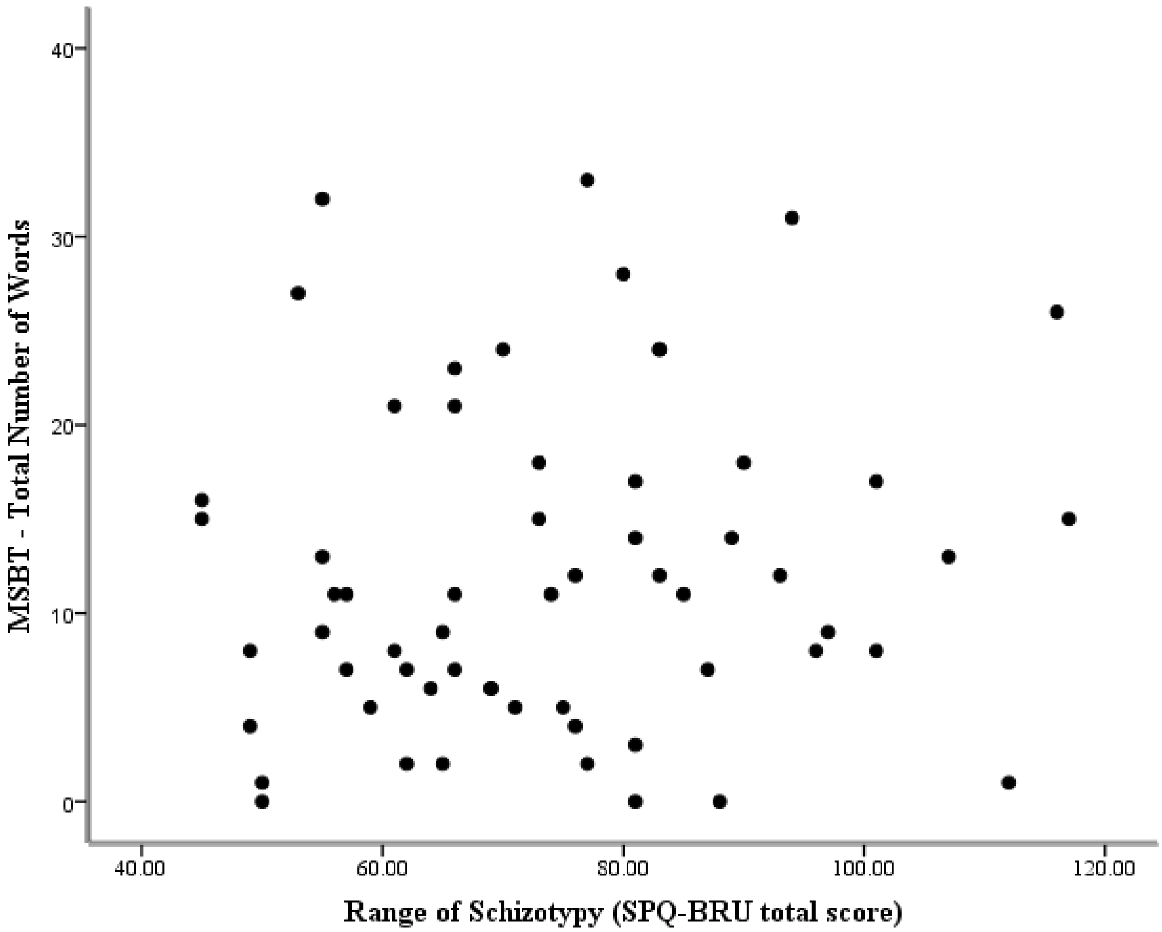

Figure 6. Scatterplot of the relationship between level of schizotypy (as measured by the SPQ-BRU) and total number of words detected.

As can be seen, in the scatterplot in Figure 7, no significant correlation was found between the level of schizotypy and the longest chain of consecutive words, r=.001, p=.993, n = 60.

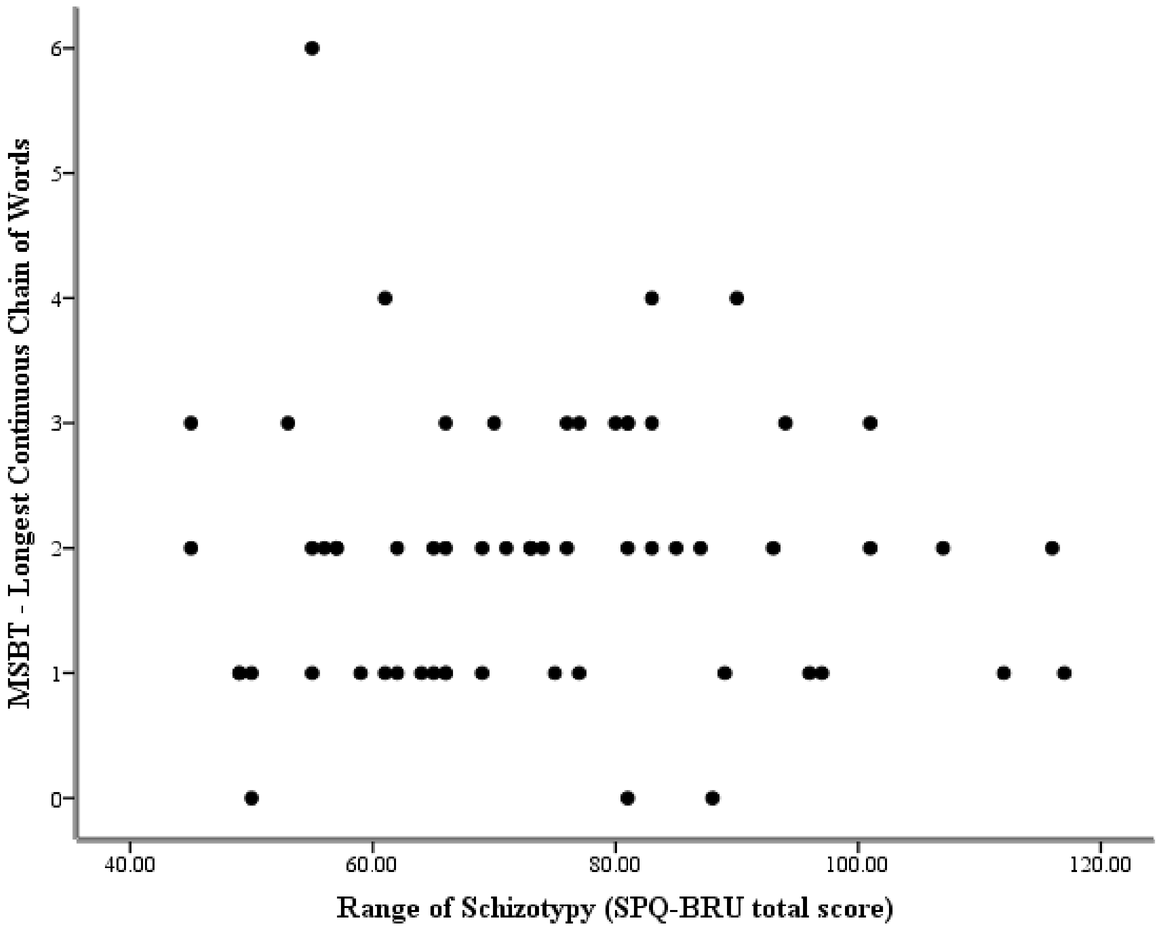

Figure 7. Scatterplot of the relationship between level of schizotypy (as measured by the SPQ-BRU) and longest chain of consecutive words.

Overall, therefore, contrary to our hypothesis, the study conducted found no association between level of schizotypy and speech illusions measured by the MSBT.

Association between Working Memory and the MSBT

To test the second hypothesis to understand how working memory is associated with scores on the MSBT, the digit span task was used to measure auditory-verbal working memory. The letter-number sequencing task was used to measure visual verbal working memory, and the Corsi block tapping task was used to measure spatial working memory.

We hypothesized that there would be a negative correlation between working memory and scores on the MSBT, with lower working memory correlating with a higher MSBT score. To test this, we conducted Pearson's correlations, for each domain of working memory, on both measures of the MSBT. As seen in Table 2, there was no significant correlation between all three working memory tasks and the number of words detected on the MSBT. Additionally, there was also no significant correlation between all three working memory tasks and the longest chain of consecutive words (see table 2). Our hypothesis was not supported as the results from the study suggest that all three working memory domains are not associated with the MSBT.

Table 2

Pearson's correlations (p value in brackets) for relationship between all working memory task and scores on the MSBT, for N=60 participants

	Digit Span Task	Letter Number Sequencing	Corsi Block Tapping Task
MSBT Total number of words	-.058 (.658)	.075 (.565)	.003 (.980)
MSBT Longest Chain of consecutive words	-.121 (.355)	.083 (.524)	-.004 (.978)

Interaction between Working Memory and Schizotypy on the MSBT

For our third hypothesis, it was hypothesized that there would be an interaction between working memory and level of schizotypy and scores on the MSBT; such that individuals with lower working memory and higher schizotypy will score higher on the MSBT. To test this hypothesis, we used moderation analyses, using the PROCESS 3 module in SPSS (Hayes, 2017). Moderation analyses were used as both the independent and dependent variables were continuous variables.

Separate moderation analyses were conducted for each of the three areas of working memory assessed, and for both the dependent variables of the MSBT; six moderation analyses in total. Additional analyses were conducted, using scores from the Mini NART as a covariate to control for intellectual functioning. However, the results of these analyses did not show any difference, and thus are not reported here.

Similarly, as the cognitive perceptual factor of schizotypy is theoretically related to speech illusions, additional moderation analyses were conducted between the cognitive perceptual factor and working memory on the MSBT. However, the results of these analyses did not show any difference, and thus are not reported here.

Moderating effect of Auditory Verbal Working Memory

Number of words detected. We regressed the number of words detected in the MSBT on auditory verbal working memory (AVWM) as measured by the millisecond digit span task, and found that there was no significant direct effect of AVWM on the number of words detected in the MSBT, $F(1,60)$=,100, p=.753. There was however, a significant increase in R^2 when the interaction between AVWM and schizotypy was added to the model, $\Delta F(1,56)=3.10$, p=.008, ΔR^2 =.117. This indicates that there was a significant interaction between AVWM and the level of schizotypy on the number of words detected in the MSBT. This interaction is shown in Figure 8. To examine the interaction, a follow up simple slope analysis was conducted to assess the relationship between schizotypy and number of words detected when AVWM was at low, mean, and high levels.

When AVWM was at low levels, there was no significant relationship between schizotypy and amount of words detected by the MSBT, b=-.154, 95%CI[-.36, .05], t=4.64, p=.14. At mean levels, again, no significant relationship was found, b=-.041, 95%CI[-.09, .17], t=.655, p=.515. However, when AVWM was at high levels, there was a significant positive relationship between schizotypy and the number of words detected in the MSBT, *b*=.237, 95%CI[.06, .41], t=2.76, *p*=.008.

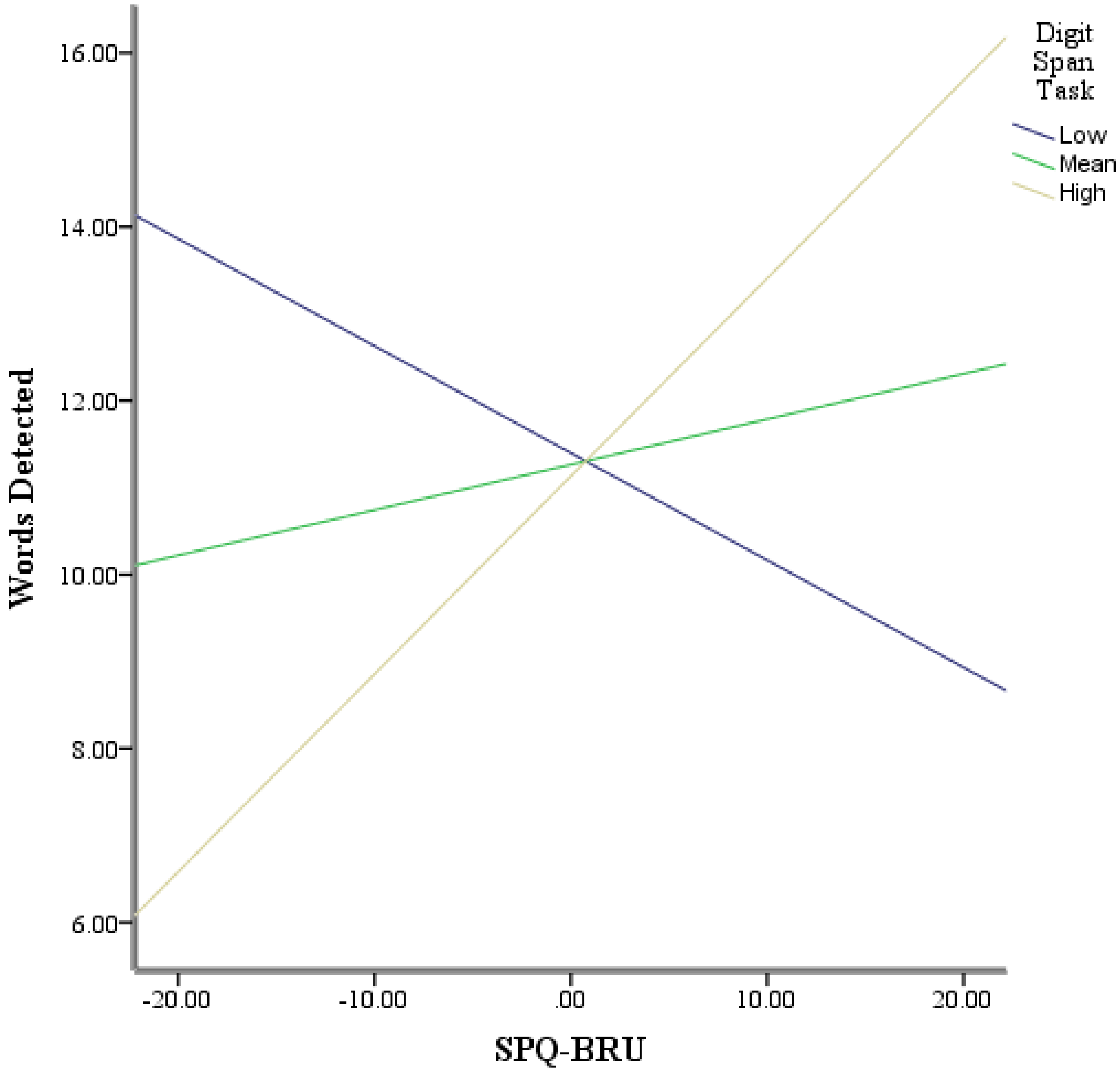

Figure 8. Simple slope graph of relationship between schizotypy (as measured by SPQ-BRU) and number of words detected in the MSBT when auditory verbal working memory was at low, mean and high levels.

Longest chain of consecutive words. We regressed the scores on the longest chain of consecutive words on AVWM, and found that there was no significant direct effect of AVWM on the longest chain of consecutive words, $F(1,60)=.87$, $p=.355$. There was also no significant increase in R^2 when the interaction between AVWM and schizotypy was added, $\Delta F(1,56)=2.47$, $p=.122$, $\Delta R^2=.04$. This indicates that there was no significant interaction between AVWM and level of schizotypy on the longest chain of consecutive words in the MSBT.

Moderating effect of Visual Verbal Working Memory

Number of words detected. We regressed the number of words detected in the MSBT on visual verbal working memory (VVWM) as measured by the millisecond letter number sequencing task, and found that there was no significant direct effect of VVWM on the number of words detected in the MSBT, $F(1,60)=.335$, $p=.565$. There was however, a significant increase in R^2 when the interaction between visual verbal working memory and schizotypy was added to the model, $\Delta F(1,56)=7.5$, $p=.008$, $\Delta R^2=.116$. This indicates that there was a significant interaction between VVWM and the level of schizotypy on the number of words detected in the MSBT. The interaction is shown in Figure 9. To further examine the interaction, a follow up simple slope analysis was conducted to assess the relationship between schizotypy and number of words detected when VVWM was at low, mean, and at high levels.

When VVWM was at low levels, there was no significant relationship between schizotypy and the number of words detected by the MSBT, $b=-.157$, 95%CI[-.36, .04], $t=-1.59$, $p=.18$. At mean levels, there was also no significant relationship, $b=-.041$, 95%CI[-.09, .17], $t=.655$, $p=.515$. However, when VVWM was at high levels, there was a significant positive relationship between schizotypy and the number of words detected in the MSBT, $b=.237$, 95%CI[.06, .41], $t=2.76$, $p=.008$.

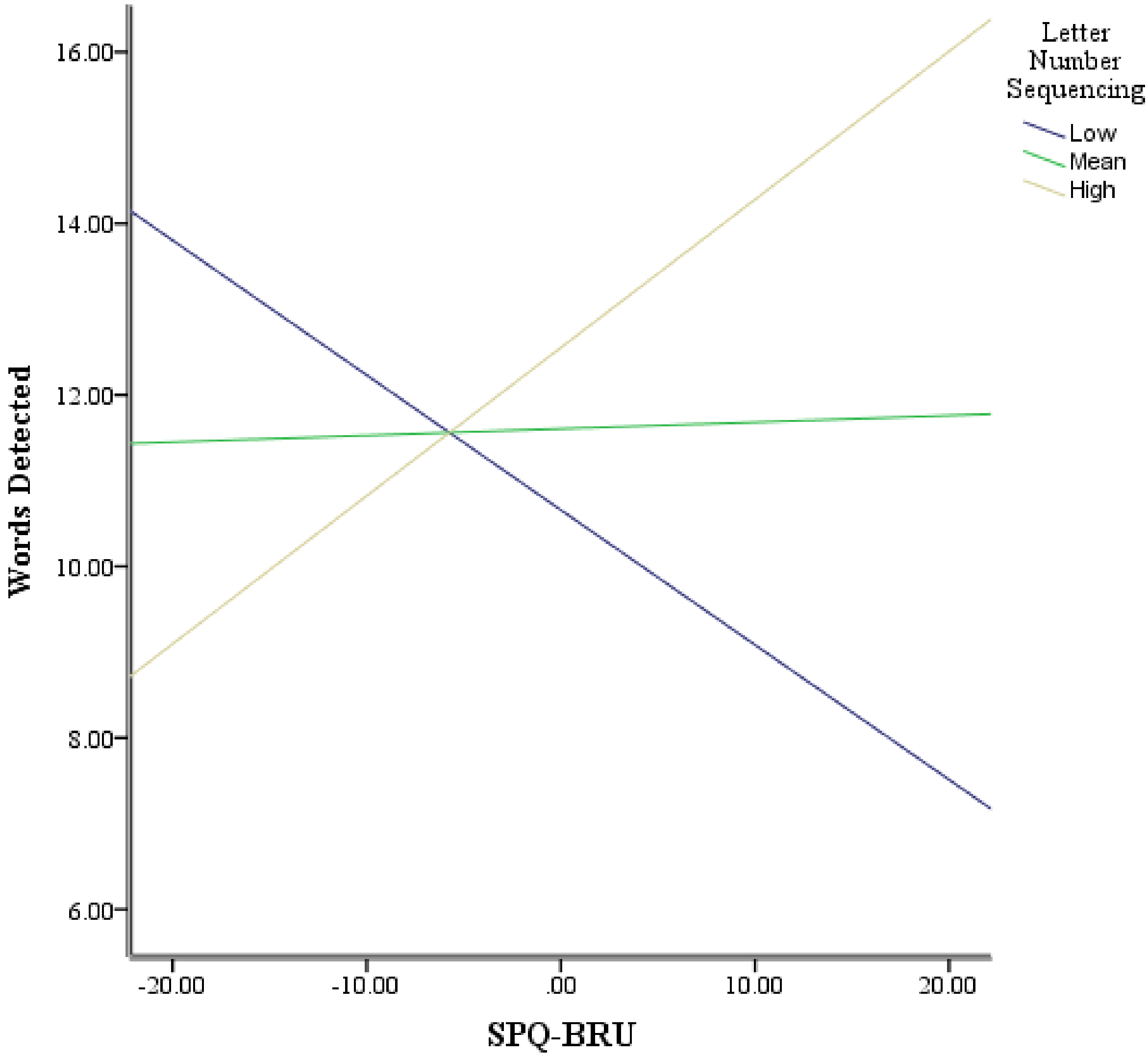

Figure 9. Simple slope graph of the relationship between schizotypy and number of words detected in the MSBT when visual verbal working memory was at low, mean and high levels.

Longest chain of consecutive words. We regressed the scores on the longest chain of consecutive words on visual verbal working memory, and found no significant direct effect of VVWM on the longest chain of consecutive words, $F(1,60)=.41$, $p=.524$. There was also no significant increase in R^2 when the interaction between visual verbal working memory and schizotypy was added to the model, $\Delta F(1,56)=2.70$, $p=.106$, $\Delta R^2 =.046$. This indicates that there was no significant interaction between VVWM and level of schizotypy on the longest chain of consecutive words scored in the MSBT.

Moderating effect of Spatial Working Memory

Number of words detected. We regressed the number of words detected in the MSBT on spatial working memory and found no significant direct effect of spatial working memory on the number of words detected in the MSBT, $F(1,60)=.001$, $p=.980$. There was also no significant increase in R^2 when the interaction between spatial working memory and schizotypy was added to the model, $\Delta F(1,56)=1.33$, $p=.255$, $\Delta R^2 =.023$. This thus indicates that there is no significant interaction between spatial working memory and level of schizotypy on the number of words detected in the MSBT.

Longest chain of consecutive words. We regressed the scores on the longest chain of consecutive words on spatial working memory and found that there was no significant direct effect of spatial working memory on the longest chain of consecutive words, $F(1,60)=.001$, $p=.978$. There was also no significant increase in R^2 when the interaction between visual verbal working memory and schizotypy was added to the model, $\Delta F(1,56)=.02$, $p=.887$, $\Delta R^2 =.001$. This therefore indicates that there was no significant interaction between spatial working memory and level of schizotypy on the longest chain of consecutive words scored in the MSBT.

Discussion

In this study, we wanted to gain a better understanding of the mechanisms underlying speech illusions in the normative population. By using schizotypy as a proxy for schizophrenia and based on previous research, we hypothesized that individuals high on the schizotypy spectrum would share similar liabilities to speech illusions as schizophrenic individuals, with the level of schizotypy positively correlating to the severity of speech illusions as measured by the MSBT. Our hypothesis however, was not supported by the study conducted as we found no correlation between the level of schizotypy and speech illusions as measured by the MSBT. Similarly, our second hypothesis was also not supported as we found no correlation between all three working memory areas and scores on the MSBT. Therefore, this indicates that working memory does not directly affect scores on the MSBT. The third hypothesis was not supported, as there was a significant interaction effect between working memory and the level of schizotypy, though it was the opposite of that hypothesized. Individuals with high schizotypy and higher working memory tended to perceive more words as measured by the MSBT than compared to high schizotypic with lower working memory. While none of our hypotheses is supported, it has yielded interesting theoretical implications, such as the interaction between working memory and liabilities to speech illusions. Through the study, we found some evidence that the mechanisms underlying speech illusions experienced by the normative population may be distinctively different from those seen in previous research on clinical and subclinical populations.

Relationship between Schizotypy and MSBT score

The hypothesis that scores on the MSBT will be positively correlated with the level of schizotypy was not supported. The initial hypothesis regarding the relationship between schizotypy and MSBT score was largely made on the basis of prior research that found correlations between the level of schizotypy and the severity of speech illusions (Galdos et al.

2010; Barkus et al., 2007; Barkus et al., 2010). More specifically, Galdos et al. (2010) utilized a signal detection paradigm similar to the MSBT and found a positive correlation between the level of schizotypy and speech illusions. In our study however, no correlation between MSBT and the level of schizotypy was found. The discrepancy between our result and that of Galdos et al. (2010) could be due to task differences between the two studies. The task used by Galdos et al. (2010), what they referred to as a "white noise task" involves participants detecting a speech stimulus embedded in a white noise condition. The difference between the white noise task and the MBST is that there is the presence of an objective reality - the presentation of an actual stimulus – in the white noise task. Galdos et al. (2010) had posited that the intermixing of audible speech within the white noise was designed to increase expectancy and invoke higher level of top-down processing. Hence, by adding a layer of audible speech, it helps to facilitate semantic and syntactic expectations and contribute to signal detection. Thus, if a participant detects words or speech in the white noise task, it might be originating either from the actual stimulus, a product of speech illusion, or a combination of both. However, the MSBT consist of purely white noise, and as such, participants should not be able to detect any objective words or speech within the task due to the complexity of the superimposed speech segments. The detection of words or speech in the MSBT suggests the presence of speech illusions. Therefore, the results found from our study, in comparison with prior research that utilizes the MSBT, suggests that the MSBT may be better suited as a clinical tool to detect speech illusions in clinical populations.

Relationship between Working Memory and MSBT score

Based on prior research, in both clinical and subclinical populations, individuals with lower working memory and other liabilities to speech illusions tend score higher on the MSBT (Hoffmann et al., 1999; Gupta et al, 2018). Motivated by the results of Hoffmann et al. (1999) and Gupta et al. (2018) study, we wanted to investigate the extent to which different aspects of working memory directly affect scores on the MSBT. Our study found no significant direct association between scores on the MSBT and all three working memory areas – auditory verbal, visual verbal and spatial working memory. Therefore, this suggests that working memory does directly affect scores on the MSBT, but rather, it may interact with liabilities to speech illusions to magnify or reduce speech illusions, depending on the circumstances.

Interaction between Working memory and Schizotypy on the MSBT

A key goal of this study was to understand how working memory interacts with various liabilities to speech illusions in the normative population to influence performance on the MSBT. Contrary to our hypothesis, our study found that there is a significant interaction between working memory and schizotypy on one measure of the MSBT.

As high schizotypic individuals share a similar cognitive style to individuals with schizophrenia, we hypothesized that the performance on the MSBT of high schizotypic individuals will be similar to schizophrenic individuals and share similar liabilities with working memory. In line with existing research in clinical (Hoffmann et al. 1999) and subclinical (Gupta et al. 2018) populations, we hypothesized that high schizotypic individuals with a lower working memory would detect more words and a longer chain of consecutive words (CCW) compared to high schizotypic individuals with a higher working memory. However, our hypothesis was not supported as we found no significant interaction effect between working memory and level of schizotypy on the measure of CCW. Nonetheless, on the measure of the number of words detected, we found that there is a significant interaction between the level of schizotypy and working memory. Contrary to prior research done in clinical and subclinical populations, we found that individuals high on the schizotypy spectrum with a stronger auditory verbal or visual verbal working memory tend to detect more words in the MSBT.

Our study was motivated by the research done by Gupta and colleagues (2018), who found an interaction between hallucination proneness and verbal working memory on the amount of words detected and the longest chain of consecutive words (CCW) as measured by the MSBT. Findings from their study suggest that the interaction between working memory and hallucination proneness in individuals not currently diagnosed with any condition, closely resembles the one seen in true clinical populations, such as those with schizophrenia. This suggested that the mechanisms underlying speech illusions in both clinical and non-clinical populations might be similar. However, it is unclear if participants that scored high on hallucination proneness (HP) in Gupta et al. (2018) study were healthy individuals' who were representative of the general population, or individuals who belong to a more subclinical or "highly at risk" category. This is because individuals that attained a high score on the hallucination prone questionnaire used by Gupta – the Launay-Slade Hallucination Scale-A – have been suggested to share cognitive, psychophysiological, and neuropsychological vulnerabilities similar to hallucinating psychotic individuals (Bentall & Slade, 1985; Launay & Slade, 1981). HP therefore, has been described in literature as a subclinical state, indicating a significant liability towards psychosis. (van Os & Linscott, 2012). To further expand on this topic and to get a better representation of the general population, our study utilized a healthy sample with the schizotypal personality trait.

In Gupta et al. (2018), the mean longest CCW for hallucination prone individuals was 2.58 (SD= 1.39), and 1.83 (SD=1.44) for the control groups. In comparison to our study, the mean longest CCW was 1.93 (SD=1.09), indicating that our sample closely resemble the healthy controls in the research done by Gupta et al. (2018). The lack of interaction found in our study as opposed to the one seen in Gupta et al. (2018) might thus be attributed to differences in population sample. Furthermore, the length of speech illusions (LSI) as denoted by the longest CCW, has been suggested to be a useful clinical tool to detect individuals from prodromal populations at risk of transitioning into schizophrenia-related disorders (Hoffmann et al., 2007). It is thus not unexpected that individuals from a healthy population to score low on the LSI. Consequently, the low CCW scores further indicates that individuals from our study were indeed from a healthy population, which was the intended group of the study.

The results from our study suggests that while the measure of CCW has useful qualities in assessing speech illusions in clinical and prodromal populations, it is not pragmatic to utilize the MSBT on a healthy population. Additionally, our results indicate a distinct difference in the interaction between working memory and liabilities to speech illusions in a normative sample in comparison with prior research conducted in clinical and subclinical samples. This suggests that there may be fundamental differences in the mechanisms facilitating speech illusions between clinical and non-clinical populations.

For the measure of words detected in the MSBT, our study found that having a stronger auditory/visual verbal working memory enabled high schizotypic individuals to pick up more salient words in the multi-speaker babble. One explanation could be attributed to the fact that having a higher working memory is usually associated with having a stronger attentional span (Cowan et al., 2005; Kuhn, 2016). Alternatively, it has also been suggested that speech illusions in some individuals might not be pathological but rather a product of an enhanced attentional mechanism (Aleman et al., 1999). Dolgov and McBeath (2015) suggested that in non-pathological individuals, individual differences in the threshold for interpreting a stimulus could facilitate object misperception. Based on Dolgov and McBeath (2015), some individuals might have a more liberal criterion when interpreting a stimulus, which thus allows them to perceive signals in the more ambient range of stimuli. Factors such as misleading perceptual information, varying attentional state, as well as expectations, might help facilitate the perception of these weakly indicated signals (Dolgov & McBeath, 2015). Hence, while these factors may be advantageous in certain scenarios, it may lead to the misperception of signals.

Dolgov and McBeath (2015) account for a population of individuals that are not perceptually deficient, but rather, they could be considered as perceptually enhanced, having more awareness of the subtle perceptual information around them. Having a stronger working memory, and consequently attentional span, would thus facilitate the perception of weakly indicated signals. This could explain why the significant interaction effect between working memory and schizotypy on the amount of words detected only occurs when working memory was at high levels, rather than at low or at mean levels. The combination of having a higher working memory, as well as misleading perceptual information from the superimposed speeches in the MSBT audio recording, might thus contribute to erroneous word detection in a normative population.

In a non-clinical population, working memory appears to facilitate speech illusions by providing linguistics expectations as well as increased attentional state to detect weakly indicated signals. However, in clinical populations, it has been suggested that the reductions in the network connectivity in the working memory systems (perceptually deficient individuals) causes linguistic expectations to become disordered and exaggerated (Hoffmann et al. 1999). Therefore, this results in the production of more perceptual errors, and consequently speech illusions. The difference in interaction effect between working memory and liabilities to speech illusions (i.e. hallucination proneness or severity of psychotic symptoms) in non-clinical and clinical populations suggest that the interaction, hypothesized in this study, may be limited to individuals who are perceptually deficient. Our results suggest that the processes underlying speech illusions in normative population may be different from that in clinical populations.

Limitations and Future Research

Firstly, a limitation of this study was the range of schizotypy. While we had a fairly normally distributed range of schizotypy scores, the range on the schizotypy spectrum was noted to be truncated around the centre of the possible distribution, containing no persons within the top 26.9% of the possible SPQ-BRU scores (see Figure 5). Therefore, the correlations between speech illusions and schizotypy might be affected as only those individuals on the maximum end of the schizotypy spectrum may display unusual perceptions such as speech illusions. Nonetheless, the range of schizotypy that we had in our sample was good and indicative of a healthy sample, in line with the target population of our study.

Secondly, while the whole experiment took participants between 45 and 60 minutes, it must be acknowledged that conducting three working memory tasks in a row, along with the other experimental tasks, may have been cognitively demanding for participants. To reduce cognitive demand, participants were encouraged by the researchers to have a break in between tasks, to ensure that they were performing to the best of their ability. Nonetheless, the cognitive demand of doing three working memory tasks may potentially have affected participants' scores.

Lastly, we wanted to replicate the results of Gupta et al. (2018) in a group that is more representative of the general population. However, due to logistic difficulties, we were unable to replicate the exact same working memory tasks. As the tasks available to us were limited, we selected and utilized tasks have been psychometrically validated and similar to the constructs that was used in the study done by Gupta et al. (2018). Furthermore, due to regulatory limitations, both the Wechsler Adult Intelligence Scale Fourth edition (WAIS-IV) could not be used to test the Letter-number sequencing, and the Wechsler Memory Scale Third edition (WMS-III) could not be used to replicate the Nonverbal span task used in Gupta et al. (2018). As a result, we used the Millisecond Corsi-block tapping task as a replacement for the nonverbal working memory task and the Millisecond Digit span task to replace the auditory verbal working memory task. As the digit span task is slightly less cognitively demanding as compared to the letter number sequencing task, it could have potentially limited the effects of working memory. Therefore, the difference in the working memory tasks used in the study may have been a potential reason behind the differences found between this study and Gupta et al. (2018). Hence, an investigation replicating the same working memory tasks that Gupta et al. (2018) would be beneficial to resolve the technical issues regarding a full replication of the study. Alternatively, a replication of Gupta et al. (2018) study with the working memory tasks used in this study may allow us to compare the results with our study and shed further insights into the differences in the liability to speech illusions in subclinical and normative populations.

Conclusion

The results from our study indicated that the interaction between working memory and liabilities to speech illusions in the normative population might very well be distinctively different from those seen in clinical populations. Therefore, theories on speech illusions based on clinical populations might not applicable to understanding speech illusions experienced by the normative population. While schizotypy can and has been used successfully as a proxy for schizophrenia to study schizophrenia-like symptomology expressed by the normative population, it may not be suitable to study speech illusions. Furthermore, the lack of correlation between the MSBT and the level of schizotypy in the normative population also suggest that the MSBT could be better used as a clinical tool to detect speech illusions in clinical populations. Future research on speech illusions should take into consideration the potential differences in mechanisms underlying speech illusions between normative and clinical populations, and consequently, their application to theories on auditory verbal hallucinations.

References

Baddeley, A. D. (1986). *Working memory*. New York, NY: Oxford University Press.

Barkus, E., Smallman, R., Royle, N., Barkus, C., Lewis, S., & Rushe, T. (2011). Auditory false perception are mediated by psychosis risk factors. *Cognitive Neuropsychiatry, 16*(4), 289-302. doi: 10.1080/13546805.2010.530472.

Barkus, E., Stirling, J., Hopkins, R., McKie, S., & Lewis, S. (2007). Cognitive and neural processes in non-clinical auditory hallucinations. *British Journal of Psychiatry, 191*(5), 76-81. doi: 10.1192/bjp.191.51.s76.

Batey, M., & Furnham, A. (2008). The relationship between measures of creativity and schizotypy. *Personality and Individual Differences, 45* (8), 816–821. doi: 10.1016/j.paid.2008.08.014

Bental, R. P., & Slade, P. D. (1985). Reality testing and auditory hallucinations: A signal detection analysis. *British journal of clinical psychology, 24,* 159-169.

Brasic, J. R. (1998) Hallucinations. *Perceptual and Motor Skills, 86*, 851–77.

Briebion, G., Stephan-Otto, C., Usall, J., Huerta-Ramos, E., Perez del Olmo, M., Cuevas-Esteban, J., . . . Ochoa, S. (2015). Association of auditory verbal and visual hallucination with impaired and improved recognition of colored pictures. *Neuropsychology, 29*(5), 667-674. doi: 10.1037/neu0000169.

Claridge, G., & Beech, T. (1995). Fully and quasi-dimensional constructions of schizotypy. *Cambridge University Press*, 192-216. doi: 10.1017/CBO9780511759031.010.

Claridge, G. (1997). *Schizotypy: Implications for illness and health.* Oxford, Ox: Oxford University Press.

Cowan, N., Elliott, E. M., Saults, J. S., Morey, C. C., Mattox, S., . . . Hismjatullina, A. (2005). On the capacity of attention: Its estimation and its role in working memory and cognitive aptitudes. *Cognitive psychology, 51*, pp. 42-100. doi: 10.1016/j.cogpsych.2004.12.001.

Daalman, K., Zandvoort, M. Van, Bootsman, F., Boks, M., Kahn, R., & Sommer, I. (2011). Auditory verbal hallucinations and cognitive functioning in healthy individuals. *Schizophrenia Research*, *132*, pp 203–207. doi: 10.1016/j.schres.2011.07.013.

Davidson, C.A., Hoffman, L., & Spaulding, W.D. (2016). Schizotypal personality questionnaire – brief revised (updated): An update of norms, factor structure, and item content in a large non-clinical young adult sample. *Psychiatry Research*, *238*, pp 345–355. doi: 10.1016/j.psychres.2016.01.053.

Dolgov, I., & McBeath, M. K. (2015). A signal detection-theory representation of normal and hallucinatory perception. *Behavioral and brain sciences*, *28*(6), pp. 761-762. doi: 10.1017/S0140525X05260132.

Fonseca-Pedrero, E., Paino, M., Lemos-Giraldez, S., Sierra-Baigrie, S., & Muniz, J. (2011). Measurement invariance of the schizotypal personality questionnaire-brief across gender and age. *Psychiatry Research 190* (2), 309-315. doi: 10.1016/j.psychres.2011.05.021

Friederici, A. D. (1983). Aphasics' perception of words in sentential context: Some real time processing evidence. Neuropsychologica, 21, pp. 351-358.

Friederici, A. D., Steinhauer, K., & Frisch, S. (1999). Lexical integration: Sequential effects of syntactic and semantic information. *Memory and Cognition*, *27*(3), pp. 438-453.

Galdos, M., Simons, C., Fernandez-Rivas, A., Wichers, M., Peralta, C., Lataster, T., . . . Van Os, J. (2011). Affectively salient meaning in random noise: A task sensitive to psychosis liability. *Schizophrenia Bulletin, 37*(6), 1179-1186. doi: 10.1093/schbul/sbq029.

Gunter, T. C., Friederici, A. D., & Schriefers, H. (2000). Syntactic gender and semantic expectancy. ERPs reveal early autonomy and late interaction. *Journal of cognitive neuroscience*, *12*(4), 556-568.

Gisselgård, J., Gøril, L., Brønnick, K., Langeveld, J., Hegelstad, V., Joa, I., Olav, J., & Ketil, T. (2014). Verbal working memory deficits predict levels of auditory hallucination in first-episode psychosis. *Schizophrenia Research*, *153*, 38–41. doi: 10.1016/j.schres.2013.12.018.

Goodman, G. O., McClelland, J. L., & Gibbs, R. W. (1981). The role of syntactic context in word recognition. *Memory and Cognition, 9,* 580-586.

Gupta, T., DeVylder, J. E., Auerbach, R. P., Schiffman, J., & Mittal, V. A. (2018). Speech illusions and working memory performance in non-clinical psychosis. *Schizophrenia Research*, *195*, 391-395. doi: 10.1016/j.schres.2017.10.031.

Hayes, A. F. (2017). *Introduction to mediation, moderation, and conditional process analysis*. London, NY: Guilford press.

Heron, J., Jones, I., Williams, J., Owen, M. J., Craddock, N., & Jones, L. A. (2003). Self-reported schizotypy and bipolar disorder: Demonstration of a lack of specificity of the kings schizotypy questionnaire. *Schizophrenia Research, 65*, 153-158.

Hoffmann, R. E., Tohen, M., Preda, A., Hawkins, K. A., Breier, A., Perkins, D., . . . Woods, S. (2007). Extracting spurious messages from noise and risk of schizophrenia-spectrum disorders in prodromal populations. *The British Journal of Psychiatry, 191*, 355-356. doi: 10.1192/bjp.bp.106.031195.

Hoffmann, R. E., & McGlashan, T. H. (1997). Synaptic elimination, neurodevelopment, and the mechanisms of hallucinated "voices" in schizophrenia. *American journal of psychiatry*, *154*(12), 1683- 1689.

Hoffmann, R. E., & Rapaport, J., Mazure, C. M., & Quinlan, D. M. (1999). Selective speech perception alterations in schizophrenic patients reporting hallucinated "voices". *American Journal of Psychiatry, 156*(3), 393-399.

Hoffmann, R. E., Rapaport, J., Rezvan, A., McGlashan, T. H., Harcherik, D., & Sevan-Schreiber, D. (1995). A neural network simulation of hallucinated "voices" and associated speech perception impairments in schizophrenic patients. *Journal of cognitive neuroscience*, 479-498.

Kalikow, D. N., & Stevens, K. N. (1977). Development of a test of speech intelligibility in noise using sentence materials with controlled word predictability. *Journal of Acoustical Society of America, 5*, 1337-1351. doi: 10.1121/1.381436.

Katz, L., Boyce, S., Goldstein, L., & Lukatela, G. (1987). Grammatical information effects in auditory word recognition. *Cognition, 25*, 235-263.

Kessels, R.P.C., van Zandvoort, M.J.E., Postma, A., Kappelle, L.J., & de Haan, E.H.F. (2000). The Corsi block-tapping task: Standardization and normative data. *Applied Neuropsychology, 7*, 252-258. doi: 10.1207/S15324826AN0704_8.

Kölmel, H. W. (1985) Complex visual hallucinations in the hemianopic field. *Journal of Neurology, Neurosurgery, and Psychiatry, 48*, 29–38.

Kuhn, J-T. (2016). Controlled attention and storage: An investigation of the relationship between working memory, short-term memory, scope of attention, and intelligence in children. *Learning and individual differences, 52,* 167-177. doi: 10.1016/j.lindif.2015.04.009.

Kwapil, T. R., & Barrantes-Vidal, N. (2015). Schizotypy: Looking back and moving forward. *Schizophrenia Bulletin, 41*(2), 366-373. doi: 10.1093/schbul/sbu186.

Lezenweger, M. F. (2018). Schizotypy, schizotypic psychopathology and schizophrenia. *World Psychiatry, 17*(1), 25-26. doi: 10.1002/wps.20479.

Mason, O., & Claridge, G. (2006). The Oxford-Liverpool inventory of feeling and experiences: further description and extended norms. *Schizophrenia Research, 82* (2). 203-211. doi: 10.1016/j.schres.2005.12.845.

Marslen-Wilson, W, & Tyler, L. K. (1980). The temporal structure of spoken language understanding. *Cognition, 8,* 1-71.

McKellar, P. (1968). *Experience and Behaviour*. London: Penguin

McGrory, S., Austin, E., Shenkin, S., Starr, J., & Deary, I. (2015). From ‘aisle’ to ‘labile’: A hierarchical national adult reading scale revealed by mokken scaling. *Psychological Assessment, 27,* 932-943. doi: 10.1037/pas0000091.

Meehl, P. E. (1962). Schizotaxia, schizotypy, and schizophrenia. *American Psychologist, 17*, 827-383.

Millisecond (2019). Inquisit 5.0 – computer software. https://www.millisecond.com.

Nelson, H. E. (1982). National Adult Reading Test (NART): Test manual. Windsor.

Nelson, H. E., & Willison, J. R. (1991). Restandardisation of the NART against the WAIS–R. In Nelson, H. E. National Adult Reading Test (NART) test manual.

Nelson, B., & Rawlings, D. (2010). Relating schizotypy and personality to the phenomenology of creativity. *Schizophrenia Bulletin, 36* (2), 388–399. doi: 10.1093/schbul/sbn098.

Nelson, M. T., Seal, M. L., Pantelis, C., & Philips, L. J. (2013). Evidence of a dimensional relationship between schizotypy and schizophrenia: A systematic review. *Neuroscience and behavioural reviews, 37*, 317-327. doi: 10.1016/j.neurobiorev.2013.01.004.

Pries, L. K., Guloksuz, S., Menne-Lothmann, C., Decoster, J., Van Winkel, R., Collip, D., Delespaul, P., De Hert, M., . . . Thiery, E. (2017). White noise speech illusion and psychosis expression: an experimental investigation of psychosis liability. *Plos One, 12*(8), doi: 10.1371/journal.pone.0183695.

Stefanis, N. C., Smyrnis, N., Avramopoulos, D., Evdokimidis, I., Ntzoufras, I., & Stefanis, C. N. (2004). Factorial composition of self-rated schizotypal traits among young males undergoing military training. *Schizophrenia Bulletin, 30* (2), 335-350.

Raine, A. (1991). The SPQ: a scale for the assessment of schizotypal personality based on DSM-III-R criteria. *Schizophrenia Bulletin*, *17* (4), 555–564. doi: 10.1093/schbul/17.4.555.

Raine, A., 2006. Schizotypal personality: neurodevelopmental and psychosocial trajectories. *Annual Reviews of Clinical Psychology, 2*, 291–326. doi: 10.1146/annurev.clinpsy.2.022305.095318.

Raine, A. (1991). The SPQ: A Scale for the Assessment of Schizotypal Personality Based on DSM-III-R Criteria. *Schizophrenia Bulletin*, *17*, 555-564. doi: 10.1093/schbul/17.4.555.

Rawlings, D., Locarnini, A. (2008). Dimensional schizotypy, autism, and unusual word associations in artists and scientists. *Journal of Research in Personality*, *42* (2), 465–471. doi: 10.1016/j.jrp.2007.06.005.

Rawlings, D., Williams, B., Haslam, N., Claridge, G. (2008). Is schizotypy taxonic? Response to Beauchaine, Lenzenweger, and Waller. *Personality and Individual Differences, 44*(8), 1663–1672. doi: 10.1016/j.paid.2008.01.021.

Van Os, J., & Linscott, R. J. (2012) Introduction: the extended psychosis phenotype – relationship with schizophrenia and with ultra high risk status for psychosis. *Schizophrenia Bulletin, 38*(2), 227-230.

Van Rossum, I., Dominquez, M., Lieb, R., Wittchen, H. U., & Van Os, J. (2009). Affective dysregulation and reality distortion: a 10-year prospective study of their association and clinical relevance. *Schizophrenia Bullein, 37* (6), 1179-1186. doi: 101093/schbul/sbp101.

Warren, R. M., & Warren, R. P. (1970). Auditory illusions and confusions. *Scientifc American, 223*, 30-36. doi:10.1038/scientificamerican1270-30.

Wechsler, D. (1997). *Wechsler Adult Intelligence Scale. Third Edition*, San Antonio, TX: The Psychological Corporation.

Woods, D. L., Kishiyama, M.M., Yund, E.W., Herron, T.J., Edwards, B., Poliva, O., Hink, R.F., & Reed, B. (2011). Improving digit span assessment of short-term verbal memory. *Journal of Clinical and Experimental Neuropsychology, 33*, 101-111. doi: 10.1080/13803395.2010.493149.

Wuthrich, V. M., & Bates, T. C. (2006). Confirmatory factor analysis of the three-factor structure of the schizotypal personality questionnaire and chapman schizotypy scales. *Journal of Personality Assessments, 87* (3), 292-304. doi: 10.1207/s15327752jpa8703_10.

Appendices

Appendix A

Screening questionnaire

Measuring auditory illusions: Investigation of a new response method for the Multi-Speaker Babble Task

Participant number: ____________

Screening Questionnaire
On the form, please enter the information requested or **tick whichever options apply to you.** **Please let me know if you feel unable to answer any of these questions.** ***Please note*** *This form is anonymous in order to protect your personal information.* *It will only be accessed by the project researchers and* *will be securely destroyed when the project is completed.* *You may withdraw at any point during the research procedure.*

1. What sex are you?

Male ☐ Female ☐ Other ☐

2. How old are you?

Years __________ Months __________

3. Do you, or have you ever had a psychosis, or a schizophrenia-related disorder?

Yes ☐ No ☐

4. Do you have a first-degree family member (brother, sister, father, mother) with a schizophrenia-related disorder

Yes ☐ No ☐

If you answered yes to either Question 3 or Question 4, we ask that you not participate study. Please talk to the researcher conducting the session to discuss this.

5. Do you have any hearing problems?

Yes ☐ No ☐

If yes, please detail the hearing problem:

____

____

____

If you answered yes to Question 5, please discuss this with the researcher conducting the session as you may not be able to participate.

6. How many hours did you sleep last night? ____________

How many hours do you usually sleep for? ____________

What time did you get up this morning? ____________

How many times did you wake up last night? ____________

Appendix B

Mini National Adult Reading Test

Mini National Adult Reading Test

AISLE

DEBT

PSALM

HEIR

DEPOT

NAUSEA

BOUQUET

NAÏVE

THYME

GIST

GAOLED

CELLIST

QUADRUPED

ABSTEMIOUS

GAUCHE

AVER

DÉTENTE

IDYLL

BEATIFY

LEVIATHAN

DEMESNE

SIDEREAL

LABILE

Appendix C

Schizotypal Personality Questionnaire – Brief Revised Updated version (SPQ-BRU)

Here are several statements that may or may not apply to you. For each question please mark (x) the extent to which you agree or disagree with each statement.

#	Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I sometimes feel that people are talking about me.	( )	( )	( )	( )	( )
2	I sometimes feel that other people are watching me.	( )	( )	( )	( )	( )
3	When shopping, I get the feeling that other people are taking notice of me.	( )	( )	( )	( )	( )
4	I often feel that others have it in for me.	( )	( )	( )	( )	( )
5	I sometimes get concerned that friends or co-workers are not really loyal or trustworthy.	( )	( )	( )	( )	( )
6	I often have to keep an eye out to stop people from taking advantage of me.	( )	( )	( )	( )	( )
7	I feel that I cannot get 'close' to people.	( )	( )	( )	( )	( )
8	I find it hard to be emotionally close to other people.	( )	( )	( )	( )	( )
9	I feel that there is no one I am really close to outside of my immediate family, or people I can confide in or talk to about personal problems.	( )	( )	( )	( )	( )
10	I tend to keep my feelings to myself.	( )	( )	( )	( )	( )
11	I rarely laugh and smile.	( )	( )	( )	( )	( )
12	I am not good at expressing my true feelings by the way I talk and look.	( )	( )	( )	( )	( )
13	Other people see me as slightly eccentric (odd).	( )	( )	( )	( )	( )
14	I am an odd, unusual person	( )	( )	( )	( )	( )
15	I have some eccentric (odd) habits.	( )	( )	( )	( )	( )

16	People sometimes comment on my unusual mannerisms and habits.	( )	( )	( )	( )	( )
17	I often feel nervous when I am in a group of unfamiliar people.	( )	( )	( )	( )	( )
18	I get anxious when meeting people for the first time.	( )	( )	( )	( )	( )
19	I feel very uncomfortable in social situations involving unfamiliar people.	( )	( )	( )	( )	( )
20	I sometimes avoid going to places where there will be many people because I will get anxious.	( )	( )	( )	( )	( )
21	I believe in telepathy (mind-reading).	( )	( )	( )	( )	( )
22	I believe in clairvoyance (psychic forces, fortune telling).	( )	( )	( )	( )	( )
23	I have had experiences with astrology, seeing the future, UFO's, ESP, or a sixth sense.	( )	( )	( )	( )	( )
24	I have felt that I was communicating with another person telepathically (by mind-reading).	( )	( )	( )	( )	( )
25	I sometimes jump quickly from one topic to another when speaking.	( )	( )	( )	( )	( )
26	I tend to wander off the topic when having a conversation.	( )	( )	( )	( )	( )
27	I often ramble on too much when speaking.	( )	( )	( )	( )	( )
28	I sometimes forget what I am trying to say.	( )	( )	( )	( )	( )
29	I often hear a voice speaking my thoughts aloud.	( )	( )	( )	( )	( )
30	When I look at a person or at myself in a mirror, I have seen the face change right before my eyes.	( )	( )	( )	( )	( )
31	My thoughts are sometimes so strong that I can almost hear them.	( )	( )	( )	( )	( )
32	Everyday things seem unusually large or small.	( )	( )	( )	( )	( )

Thank you for filling out this questionnaire.

Appendix D

Participant information sheet

UNIVERSITY OF TASMANIA

Measuring auditory illusions: Investigation of a new response method for the Multi-Speaker Babble Task

Chief Investigator:	Dr Michael Quinn
Co-Investigator:	Ms Val Ranson
Student Investigators:	Rachel Barac & Tristan Chooi

Invitation
You are invited to participate in a research study looking at the development of a new way of responding to a task that investigates auditory perception. The study is being conducted at the University of Tasmania by Michael Quinn & Val Ranson, Rachel Barac & Tristan Chooi. Rachel & Tristan are using some of the information collected to complete their research theses, as part of the Honours degree in Psychology.

What is the purpose of this research?
Individuals vary in the extent to which they are able to pick out words when many people are speaking all at once. There are many ways to investigate how and when people do pick out individual words and phrases from “babble”, and this study is trying to identify the most effective means of measuring this perceptual process. in the Multi-Speaker babble Task, people are asked to speak aloud whenever they are able to detect a word or a phrase. We are interested in investigating whether a simpler response, such as pressing a button, would be more effective.

Why have I been invited to participate?
You have been invited to participate because you have expressed interest in the research.

We would like to recruit people who are also:

- Over 18 years of age

- Of normal hearing (hearing problems may change how the brain processes sound).
- With *no* history of psychosis, or schizophrenia-related disorder, or a first-degree family member (brother, sister, father, mother) with a schizophrenia-related disorder. This is because
    - A person who has or has had psychosis or a schizophrenia-related disorder often experiences auditory hallucinations – which involves perceiving sounds without an auditory stimulus (e.g. hearing a voice when there's no one around).
    - While this study is looking at how people are able to pick out words when many people are speaking all at once, a person who has experienced auditory hallucinations often performs differently on this task.
    - A person with a family member with a schizophrenia-related disorder is often more susceptible to auditory misperceptions, and therefore may also perform differently on the Babble Task.

If you are under 18, have poor hearing, or have a history of psychosis, or schizophrenia-related disorder, we ask that you do not participate.

Participation in the research is completely voluntary. If you decide not to take part or if you decide to withdraw at any point, there will be no penalties. Your involvement with the University of Tasmania and the Division of Psychology will not be affected in any way.

If you agree to participate, we will ask you to sign a Statement of Informed Consent. The Statement of Informed Consent specifies the information that must be fully explained to you.

What will I be asked to do?
You will be asked to attend a one (1) hour session at an agreed location at the University of Tasmania, and asked to complete several short tasks.

These include:

- Complete a screening questionnaire that collects basic, non-identifiable, demographic information, such as your age and gender
    - You will also be asked to confirm that you do not have poor hearing, and do not have a history of psychosis, or schizophrenia-related disorder.
- Listen to a recording of many people talking at once and be asked to repeat outloud any words or phrases that you hear in the 'babble'.
- Listen to a recording of many people talking at once and be asked to press a button whenever you hear a word or phrase in the 'babble'.
- Complete three tasks measuring working memory – the part of memory that temporarily holds and processes information. Working memory plays a

significant role in auditory perception, and this is why we are doing those tasks. There are three tasks that you will be asked to complete:
    - Listen to some numbers and recall them in the same order, or reverse order.
    - See some numbers and letters presented on the screen and recall them in order.
    - See some square shapes on a screen light up, and recall the order in which they light up.
- Complete a test of vocabulary that assesses intellectual functioning. For this task, you will read aloud a list of words that have irregular spellings. In the data analysis, this will enable us to account for any significant differences in intellectual functioning among participants. (Please note that this is *not* an IQ test; an individual's score, on its own, will not mean anything.)
- A questionnaire about your personality
    - People vary in the extent to which they are likely to have unusual perceptions.
    - This is part of a regular personality characteristic called schizotypy.
    - Your score on this questionnaire in no way indicates the presence of a mental illness, or whether you are likely to develop a mental illness

Are there any possible benefits from participation in this study?
If you decide to participate in this study, you will be helping us to develop better ways to understand and investigate the processes that are involved in being able to pick out words when many people are speaking all at once.

If you are a first-year psychology student in this group, you are eligible to receive one (1) hour of course credit for your research participation.

Or, you can enter a draw to receive one (1) of five (5) $30 giftcards (you can choose from Coles, Woolworths, iTunes, or Google Play Store giftcards).

Are there any possible risks from participation in this study?
There are no known risks from this study.

What will happen to the information when this study is over?
Your individual data will be strictly confidential. Your name will not be recorded with any data. Instead, your data will be given an individual identification number. All data will be kept in locked cabinets or on password-secured computers in the Division of Psychology at the University of Tasmania.

Your data will be used Rachel Barac & Tristan Chooi to complete a research thesis, as part of their Honours degree in Psychology. It will also be used by the research team to prepare research articles for publication, though you will not be identifiable in any way,

You will also be asked whether your data – in completely deidentified form (i.e. in a way you cannot be personally identified) – can be used in future research projects in the same general area of research by the Chief Investigator Dr Michael Quinn, and Co-Investigator, Ms Val Ranson. If you consent to the use of these data in parallel future research projects, then your data will be destroyed five years following the last publication arising from the use of the data.

You can choose not to do allow the use of your data in parallel future research projects, and only have your data used in this research study. Then your data will be destroyed five years following the completion of this research study.

You can indicate whether you want your data used in parallel future research projects, or only in this research study, by ticking the relevant box on the consent form.

What if I change my mind during or after the study?

You are free to withdraw from the study at any time without penalty. This means that a decision to withdraw from the study will not affect your involvement with any service or with the University of Tasmania. You may decide to end your participation or to withdraw altogether from the study, without explanation. You can do so at any time up to 2 months after your participation in the study, by emailing the Chief Investigator, Dr Michael Quinn.

How will the results of the study be published?

Following completion of the research, the data will be published as articles in professional journals (peer-reviewed) and presented at conferences. It will not be possible to identify an individual participant.

A summary of the results of these experiments will also be available on the University of Tasmania School of Medicine (Psychology Division) webpage. The summary will also be available by contacting the researchers.

What if I have questions about this study?
This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee, Approval No. H0018214.

If you have any questions about the study, you can contact any member of the research team:

Chief Investigator:	Dr Michael Quinn	Michael.Quinn@utas.edu.au
		(03) 6226 2998
Co-Investigator:	Ms Val Ranson	Val.Ranson@utas.edu.au
Student Investigators:	Rachel Barac	rbarac@utas.edu.au
	Tristan Chooi	Tristan.Chooi@utas.edu.au

If you have concerns or complaints about the conduct of this study, you can contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 6254 or email ss.ethics@utas.edu.au. The Executive Officer is the person nominate to receive complaints from research participants. You will need to quote H0018214.

Please keep this Information Sheet in case you wish to refer back to it later.

If you would like more information or if you wish to participate in the study,

do please contact us.

Appendix E

Participant consent form

UNIVERSITY OF TASMANIA

Measuring auditory illusions: Investigation of a new response method for the Multi-Speaker Babble Task

Chief Investigator:	Dr Michael Quinn
Co-Investigator:	Ms Val Ranson
Student Investigators:	Rachel Barac & Tristan Chooi

Participant Statement of Informed Consent

1. I agree to take part in the research study named above.
2. I have read and understood the Participant Information Sheet for this study.
3. The nature and possible effects of the study have been explained to me.
4. Any questions that I have asked, have been answered to my satisfaction.
5. I understand that the study requires me to attend a laboratory space in the Division of Psychology, School of Medicine at the University of Tasmania for one (1) hour.
6. I understand that I will be asked questions about my personal history that are relevant to the study.
7. I understand that I will be asked to complete a range of tasks, as outlined in the Participant Information Sheet.
8. I understand that participation involves no identifiable risks.
9. I understand that all research data will be treated as confidential, and that electronic data will be stored securely on password-protected computers and hard copy information in locked filing cabinets only accessible by the investigators.
10. I agree that the research data gathered for the study will be used by Rachel Barac and Tristan Chooi in the research thesis component of the Honours degree in Psychology. The use of the data by these students will be in a form that means that I cannot be identified as a participant in this thesis.
11. I also understand that the research data may be published in academic papers by the Chief Investigator and Co-Investigator, provided that I cannot be identified as a participant.
    I understand that the data will be kept for a period of 5 years following the last publication from the data, after which the data will securely destroyed, unless I give permission for it to

be used in parallel research projects by Chief Investigator Dr Michael Quinn, and Co-Investigator, Ms Val Ranson

☐ I agree that my study data can be used for this specific project, but NOT for any other project

☐ I agree that my de-identified study data can be used for future research projects in the same general area of this research by the Chief Investigator Dr Michael Quinn, and Co-Investigator, Ms Val Ranson

12. I understand that my participation is voluntary and that I may withdraw from participation at any time up to 2 months after my participation in the experiment. If I decide to withdraw, this will not affect my academic standing or my involvement with the researchers or Division of Psychology in any way. I may withdraw my data at any time up to three months after my participation in the research, by contacting the Chief Investigator.

Participant’s name: ____

Participant’s signature: ______________________________________ Date: ___________

Investigator Statement

I have explained this research and the implications of participation in it to this volunteer and I believe that the consent is informed and that he or she understands the implications of participation.

Investigator’s name: ____

Investigator’s signature: ______________________________________ Date: ___________

Appendix F

Ethics approval form

UNIVERSITY of TASMANIA

02 July 2019

Dr Michael Quinn
C/- University of Tasmania

Sent via email

Dear Dr Quinn

REF NO: H0018214
TITLE: Measuring auditory illusions: Investigation of a new response method for the Multi-Speaker Babble Task

We are pleased to advise that acting on a mandate from the Tasmania Social Sciences HREC, the Chair of the committee considered and approved the above project on 02 July 2019.

Please ensure that all investigators involved with this project have cited the approved versions of the documents listed within this letter and use only these versions in conducting this research project.

This approval constitutes ethical clearance by the Tasmania Social Sciences HREC. The decision and authority to commence the associated research may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or review by your research governance coordinator or Head of Department. It is your responsibility to find out if the approvals of other bodies or authorities are required. It is recommended that the proposed research should not commence until you have satisfied these requirements.

In accordance with the National Statement on Ethical Conduct in Human Research, it is the responsibility of institutions and researchers to be aware of both general and specific legal requirements, wherever relevant. If researchers are uncertain they should seek legal advice to confirm that their proposed research is in compliant with the relevant laws. University of Tasmania researchers may seek legal advice from Legal Services at the University.

All committees operating under the Human Research Ethics Committee (Tasmania) Network are registered and required to comply with the *National Statement on the Ethical Conduct in Human Research* (NHMRC 2007 updated 2018).

Therefore, the Chief Investigator's responsibility is to ensure that:

(1) All investigators are aware of the terms of approval, and that the research is conducted in compliance with the HREC approved protocol or project description.

(2) Modifications to the protocol do not proceed until **approval** is obtained in writing from the HREC. This includes, but is not limited to, amendments that:

UNIVERSITY of TASMANIA

(i) are proposed or undertaken in order to eliminate immediate risks to participants;
(ii) may increase the risks to participants;
(iii) significantly affect the conduct of the research; or
(iv) involve changes to investigator involvement with the project.

Please note that all requests for changes to approved documents must include a version number and date when submitted for review by the HREC.

(3) Reports are provided to the HREC on the progress of the research and any safety reports or monitoring requirements as indicated in NHMRC guidance. Researchers should notify the HREC immediately of any serious or unexpected adverse effects on participants.

(4) The HREC is informed as soon as possible of any new safety information, from other published or unpublished research, that may have an impact on the continued ethical acceptability of the research or that may indicate the need for modification of the project.

(5) All research participants must be provided with the current Participant Information Sheet and Consent Form, unless otherwise approved by the Committee.

(6) This study has approval for four years contingent upon annual review. A *Progress Report* is to be provided on the anniversary date of your approval. Your first report is due 02 July 2019, and you will be sent a courtesy reminder closer to this due date. Ethical approval for this project will lapse if a Progress Report is not submitted in the time frame provided

(7) A *Final Report* and a copy of the published material, either in full or abstract, must be provided at the end of the project.

(8) The HREC is advised of any complaints received or ethical issues that arise during the course of the project.

(9) The HREC is advised promptly of the emergence of circumstances where a court, law enforcement agency or regulator seeks to compel the release of findings or results. Researchers must develop a strategy for addressing this and seek advice from the HREC.

Should you have any queries please do not hesitate to contact me on (03) 6226 2975 or via email ss.ethics@utas.edu.au.

Yours sincerely

Jude Vienna-Hallam
Executive Officer I Social Sciences

Human Research Ethics Committee (Tasmania) Network
Research Ethics and Integrity Unit
Office of Research Services
Private Bag 1
Hobart Tasmania
7001
Australia
T +61 3 6226 2975
E ss.ethics@utas.edu.au
ABN 30 764 374 782 /CRICOS 00586B
utas.edu.au